Volume 3 Number 4 July/August, 1966

Information Display

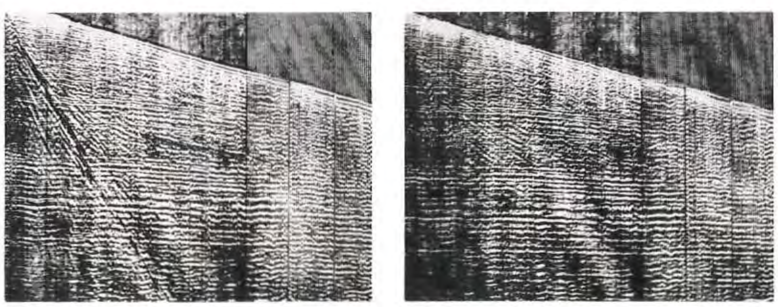
Journal of the Society for Info

Dr. Milton B. Dobrin, United Geophysical Corporation, Pasadena, demonstrates optical filtering technique used to enhance seismic data.

Laser helps seismic prospectors dig deeper

There's a vast fortune in oil to be found on seismic charts already recorded, from fields already explored. The trick is in enhancing the seismic data, in separating the significant information from noise, surface waves, diffractions, and other spurious events which obscure desired reflections. You can do it, if you can afford it and have the patience, with standard analog and digital processing methods. But if you want to dig deeper, processing hundreds of data channels at a time and monitoring the results at all stages, there's now another way to look at your data.

A new technique[1], called Laserscan[2], processes seismic data using optical filtering methods. When spatially coherent light is passed through a seismic "section" on photographic film, the seismic signals act as an optical grating to produce a diffraction pattern. By "doctoring" the diffraction pattern, then converting it back into an image of the original section, it is possible to remove unwanted frequency or directional components. Key to the success of the method is the intense, spatially coherent monochromatic light from a Spectra-Physics CW gas laser.



Seismic sections showing (left) reflections crossed by high-velocity and low-velocity noise, and (right) same section with high- and low-velocity events removed by optical filtering.

Similar optical data processing methods enable the removal of raster lines from televised photos, for example, or the subtraction of interference and noise to improve visual display of low-level signals. Whether you are prospecting for oil or ideas, it may pay you to investigate other ways in which the CW gas laser has found commercial application. If you'd like to be on our mailing list to receive Laser Technical Bulletins, write us at 1255 Terra Bella Avenue, Mountain View, Calif. 94040. In Europe, Spectra-Physics, S.A., Chemin de Somais 14, Pully, Switzerland.

Spectra-Physics

[1] MILTON B. DOBRIN, ARTHUR L. INGALLS, AND JAMES A. LONG, 1965, VELOCITY AND FREQUENCY FILTERING OF SEISMIC DATA USING LASER LIGHT: GEOPHYSICS V. 30, PP. 1148-1178.

[2] TRADE MARK, CONDUCTRON CORPORATION

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Published bi-monthly by
Information Display Publications, Inc.
647 North Sepulveda Boulevard
Bel Air, Los Angeles, Calif. 90049
(213) GR 6-4711

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Volume 3 Number 4 July/August, 1966

Information Display

Journal of the Society for Information Display

ARTICLES

FEATURES

THE COVER

The history of numerical communication is depicted in this composite of photos by Robert W. Young, and art as well as over-all design by Al Dougherty, both of TRW Systems, Redondo Beach, California. Top tier depicts earliest form (finger counting) keyed by modern ball callouts; middle tier represents verbal communications (sounds formed by lips); bottom tier portrays modern numeric readouts.

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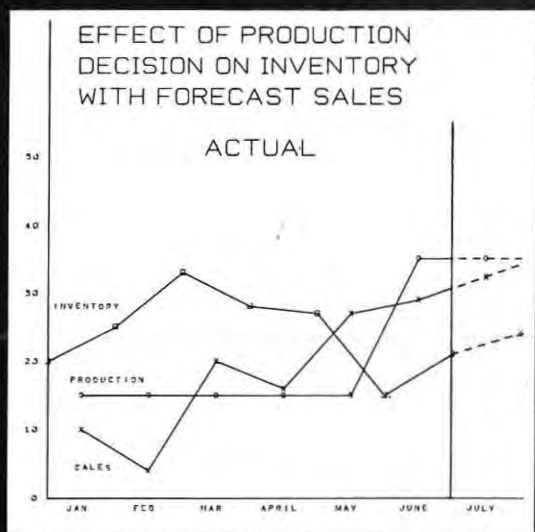
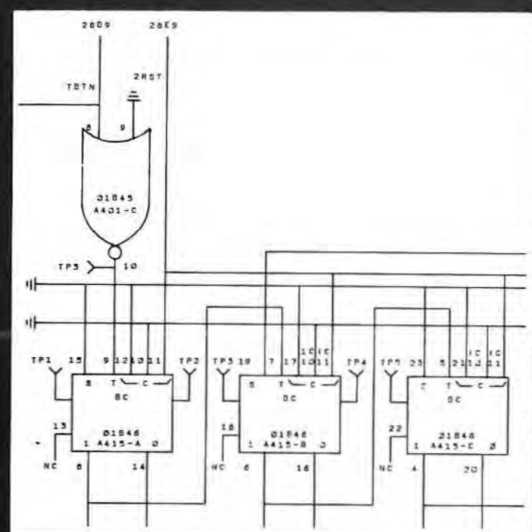
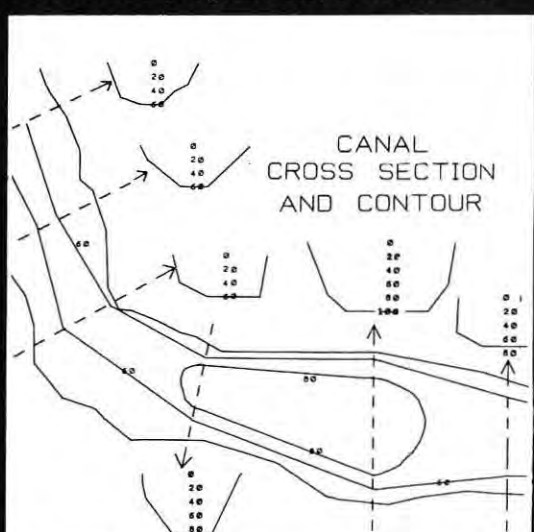


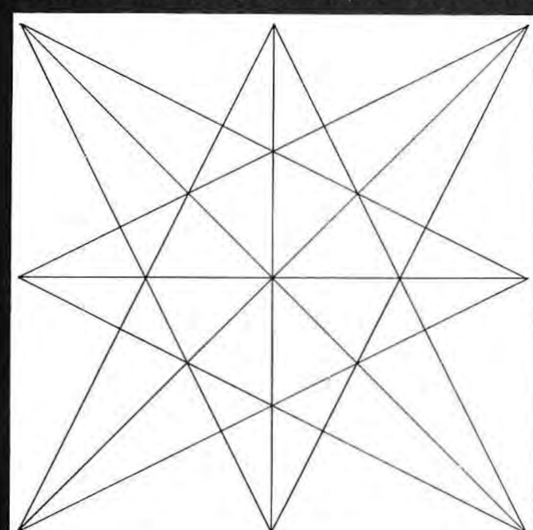
Before: 450 program steps. **Now:** 300



Before: 1000 program steps. **Now:** 700



Before: 600 program steps. **Now:** 500



Before: 54 program steps. **Now:** 14

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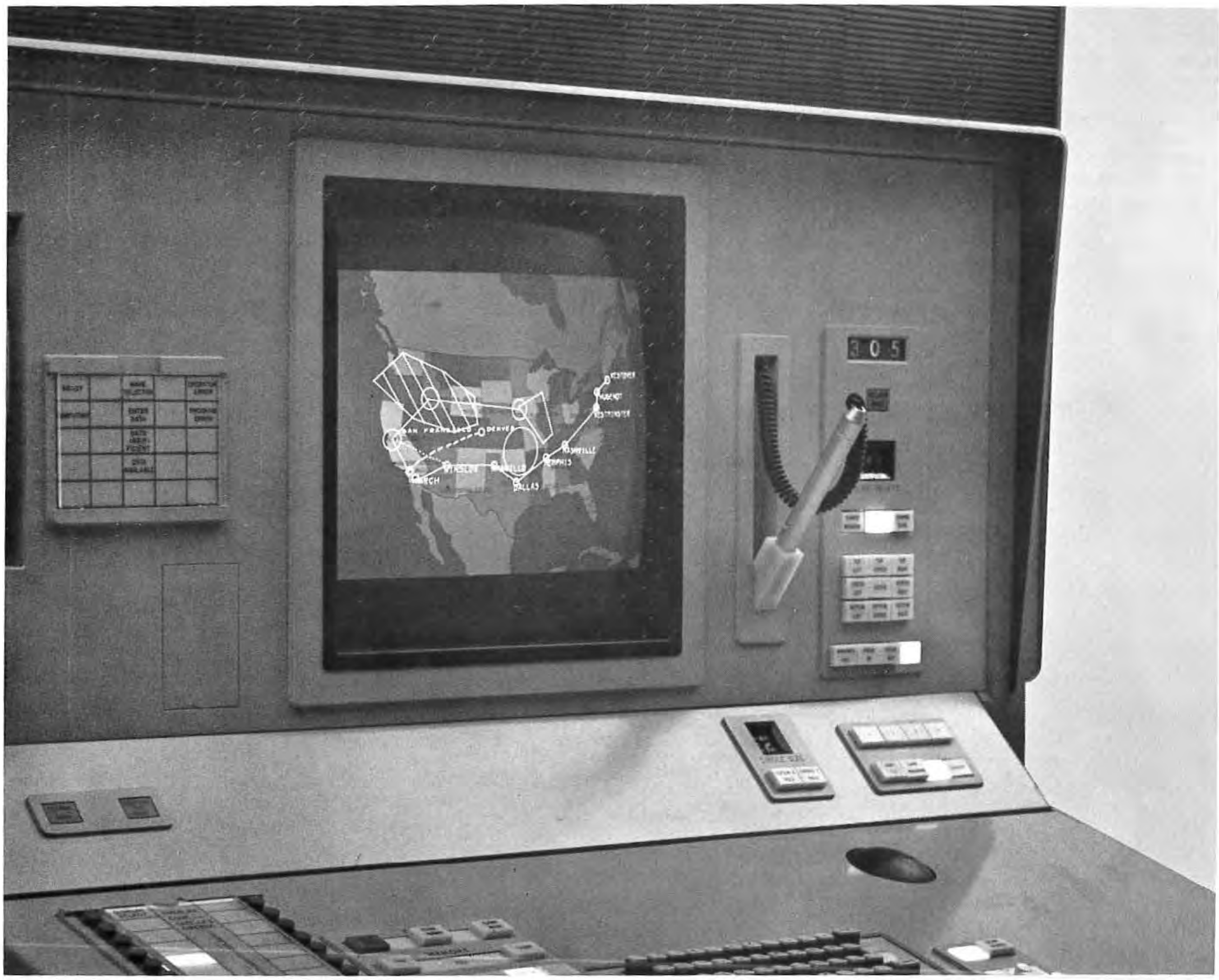

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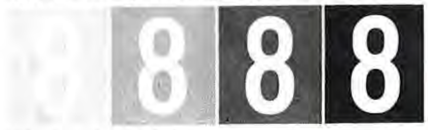

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EDITORIAL

OUR GROWING SPECIALIZATION

Information display as a recognized and distinct field of technology is relatively new. In fact, this writer was engaged principally in information display for a quarter of a century before recognizing the existence of it as a technology with a name. Our young, growing organization and its Journal are evidence of the increasing need for technical communication among persons whose interests relate in some fashion to the field.

However, this need for technical communication carries with it a very interesting and very real problem. It is probably as difficult to categorize the special interests of persons working in the broad area of information display as it would be to predict its direction and growth in the future.

Information display technology is truly interdisciplinary, requiring a more catholic approach to the problem of technical communication perhaps than many other technical societies. *SID* has a great opportunity to advance technical knowledge in many fields as they relate to information display. In seeking better ways of information display we are calling on the services of the psychologist, the engineer, the physicist, chemist, mathematician and other specialists, working in a bewildering array of special fields within their areas of special training.

There is a need to identify display specialists – as opposed to those who are involved in peripheral or sporadic contacts with the field – because this is the group whose participation is so vital to technological advancement and to *SID* growth. Perhaps some standards can be established to define the "display man" in precise terms. Eventually, such standards might be revised or extended to provide a basis for assessing levels of professional expertise. As our technology becomes increasingly sophisticated, we must surely strive to make our Society the arbiter of standardization for both product paramaters and professional performance.

Our technology is inexorably linked with two rapidly growing phenomena – the giant digital computer and automated high density information storage and retrieval systems. It is being said by many that we are in the midst of an information explosion – that we are generating important information at rates far beyond those of a few years ago. New ways must be found to store, call up and use this information if we are to progress or even to avoid bogging down in a mass of paper work.

We all look forward, from the vantage point of our respective specialties, to continuing growth of the Society. We believe that this growth, paralleled with increasing effectiveness, will come about through recognition of the nature of our task and the steady improvement of our technical meetings and publications. We hope that as we grow we are able to recognize the various specialties that make up the spectrum of the Society's interests and while not aiming to be something to everyone, be at least significant to many.

FORDYCE BROWN
Northeast Regional Director, and
Chairman, Convention Committee
Society for Information Display

Fordyce M. Brown is president of Photomechanisms Inc., Huntington Station, New York. He was Chairman of the SID 6th National Symposium in New York in 1965, and is presently Chairman, Convention Committee, as well as Northeast Regional Director of the Society.

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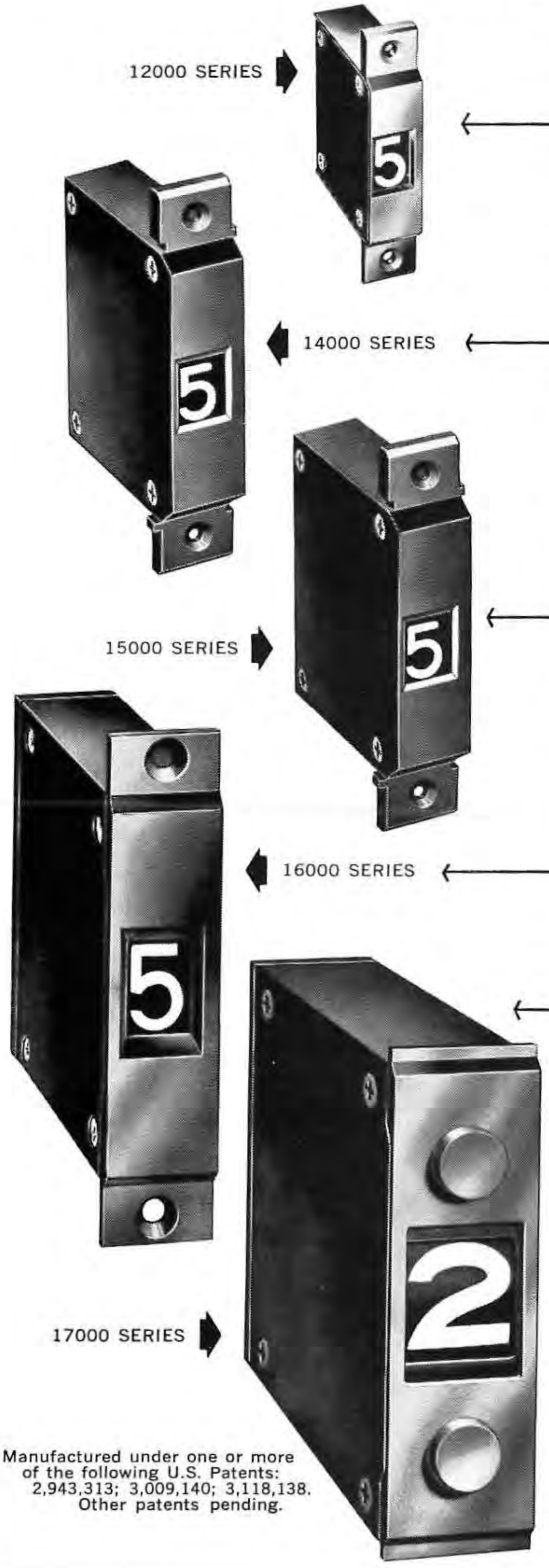

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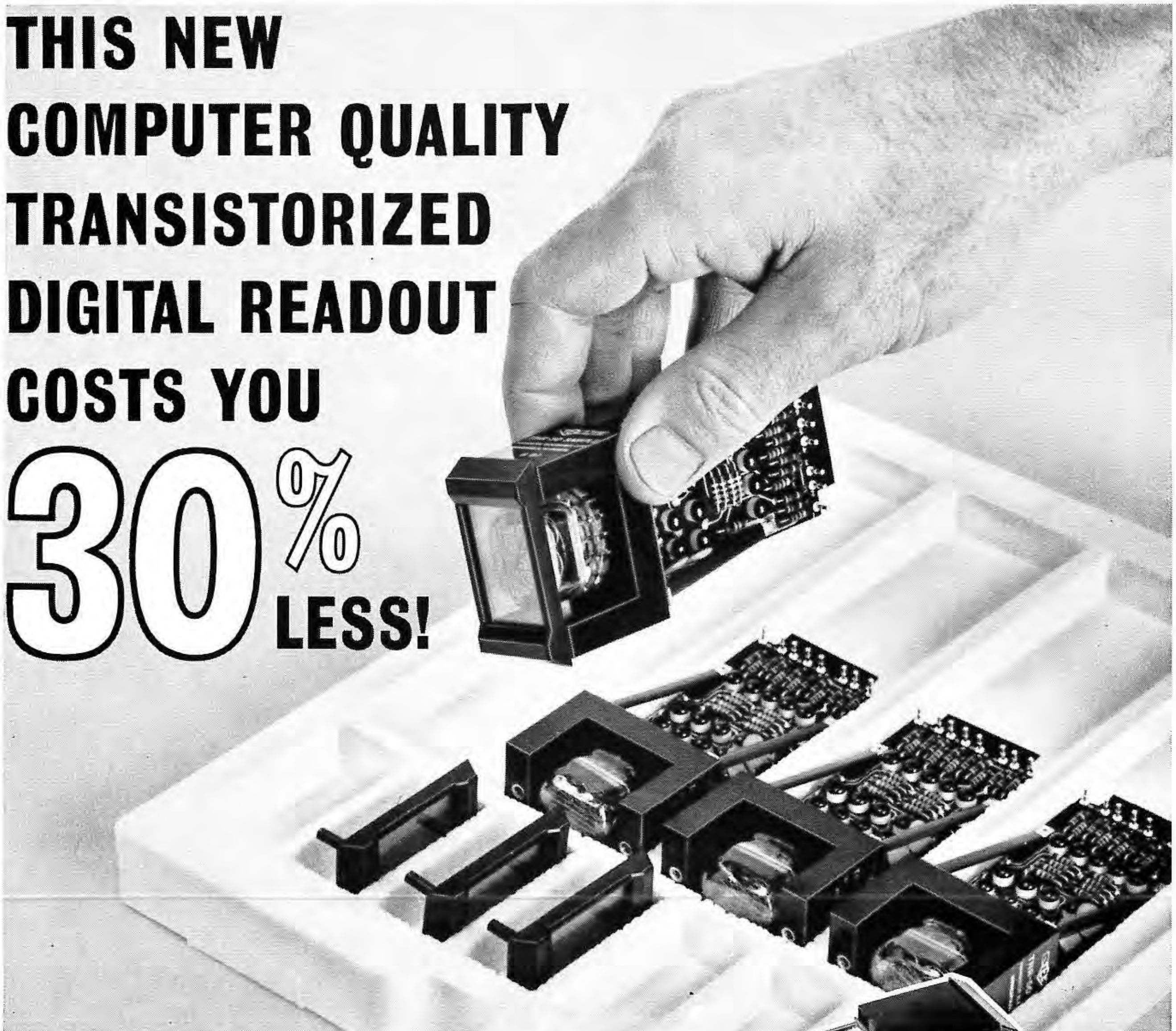

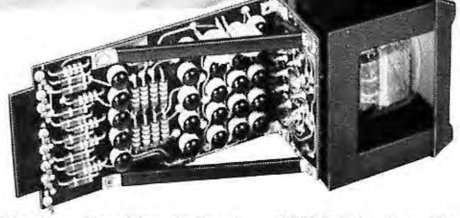

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Concept for Design And Implementation Of Mobile, Computer-Generated Display Systems

by Paul Horowitz

IBM Federal Systems Division
Space Guidance West

[This paper was prepared while the author was associated with Northrop Nortronics, Anaheim, California, and was presented at the Sixth National Symposium of the *Society for Information Display*. It was first published in the *Proceedings* of that meeting. Mr. Horowitz is now associated with the IBM Federal Systems Division, Space Guidance West.]

Abstract

The purpose of this report is to discuss several computer generated display concepts that appear to be suitable for use in tactical operations centers. The report does not present a survey or review of data display "state-of-the-art", but attempts to set forth the human and subsystem requirements of tactical centers in general, as well as some that may be unique to a particular system. The display subsystem design described in the report is within the current state-of-the-art and could be available without an extensive research and development program.

Introduction

It is generally accepted that the modern tactical command and control center must be mobile; this does not mean that it must be operable while in motion, but that it should be readily transportable. The transportability requirement imposes added burdens on the system that are not ordinarily placed upon a stationary command-post system. This includes requirements for: lightness in weight, greatly increased reliability, remove - and - replace maintenance, and adaptability to an extremely wide range of environments. Of major importance is logistic support (e.g., ammunition or lower priority expendables). The displays postulated in this paper are, directly or indirectly, computer driven (i.e., they will use processed rather than raw data) and must convey information to the user in the most efficient form.

The factors that influence design are extremely complex because of the varied and, at times, conflicting system requirements (such as low cost versus high reliability). Those factors that specifically influence display subsystem design include: subsystem environment, general physical characteristics, subsystem operational requirements, display presentation characteristics, and display quality.

Mobile systems operate in varying areas and under varying ambient conditions. This type of system may place requirements and limitations on the display subsystem. The techniques of solid-state and subminiature electronic design must be fully exploited in order to provide displays that can be used by these systems. A display subsystem designed for a mobile system can easily be used in the relatively stable environment of a permanent command and control center. Operational characteristics of the display subsystem include the quantity of data that must be displayed and assimilated by the user within a given time frame, the human response time (as a variable of the rate at which the data may be assimilated), update and request time. These characteristics vary in their relative importance as functions of total system requirements.

The characteristics of a particular display presentation are the form or quality of the presentation. The presentation form is the basic configuration (e.g., map or topographic presentation, pictorial, symbolic, or combinations of these). Display presentation quality is affected by resolution, contrast, distortion, accuracy, tone, and color.

The techniques and devices needed to readily implement the mobile display subsystem are not available in large variety. This may be attributed to present state-of-the-art, availability within the time period under consideration, and the diverse environmental and operational requirements demanded. There are many characteristics which directly influence the choice of components and subsystems. The display subsystems must be meticulously selected, designed, and tested prior to field use. Several display techniques are readily adaptable to the rigors of field use and in turn can form the basis of several versatile, flexible display subsystems.

Factors that Influence Design

The factors that influence design are extremely complex because of the varied and, at times, conflicting system requirements (such as low cost versus high reliability). Those factors that specifically influence display subsystem design include: subsystem environment, general physical characteristics, subsystem operational requirements, display presentation characteristics, and display quality (reference 1).

Environmental

The subsystem environment is one of alternating periods of operation, maintenance, storage, and shipment, which may occur in a land, sea, air or space ambience. Each situation has unique and varying conditions that may adversely affect equipment operation. These conditions may be categorized as natural and induced. The natural conditions include: nuclear and solar radiation, humidity, ambient temperature, pressure, and ambient salinity. Other natural conditions, such as Van Allen and cosmic radiation and high vacuum, are necessary considerations only in space applications. The induced conditions include: mechanical and acoustic vibration, acceleration, induced temperature, and shock.

From the environmental point of view, a display subsystem is similar to other electronic devices in most respects, and the requirements for survival in adverse environments do not differ greatly. Certain display aspects, usually photo-optical and mechanical devices and techniques, require special environmental design considerations. Optical devices may crack or become unaligned after vibration and shock exposure; vibration and shock exposure may not affect electronic components of the subsystem. Mechanical components may corrode from exposure to relatively light salinity, and may "freeze" as a result of temperature extremes. Silver halide photographic emulsions will become fogged if exposed to ionizing radiation. Kalvar photographic materials will lose sensitivity when exposed to ultraviolet radiation. These environmental factors are extremely important, especially when the display concepts or techniques which are under consideration have no standard external operating environment.

Physical Characteristics

Physical characteristics of the subsystem are important in the context of stringent payload requirements for space and airborne missions and "man-liftable" requirements for many Army operational and maintenance considerations. Military specifications state that a man must not carry more than 35 pounds, though he may lift weight in excess of this. The total area that each component must occupy, and the physical relation of one to the other are as important as the total area the display subsystem requires, inasmuch as space is limited and area configuration may not be readily modified, especially within a mobile system.

Operational Characteristics

Mobile systems operate in varying areas and under varying ambient conditions. This type of command and control system places severe requirements and limitations on the display subsystem. The techniques of solid-state and subminiature electronic design must be fully exploited in order to provide displays that can be used by these systems. A display subsystem designed for a mobile system can be used easily in the relatively stable environment of a permanent command and control center. Operational characteristics of the display subsystem include the quantity of data that must be displayed within a given time frame, the human response time (as a variable of the rate at which the data may be assimilated), update and request times. These characteristics vary in their relative importance as functions of total system requirements.

Data Quantity

The amount of data that can be displayed is dependent upon two factors: the availability of data, either raw (radar scan) or processed (computer output), and the response or ability of the user to perceive and understand the information displayed. Some displays present system data in toto (such as radar) and constantly repeat the display in an unvarying time frame, which is a function of antenna rotation time. Other systems using "processed or stored" data can present data upon user request of update or change when he has understood or responded to the information that concerns him. Many display subsystems "categorize" data into varying formats, depending upon the user level and function. The formation of data categories for display is a complex processing problem that involves user requirements, file organization, classification, indexing, data entry, and other data processing considerations. The "format" of displayed information usually presents data in a form easily understood by the user and can be tailored to meet his individual information requirements (reference 1).

The major physiological limitation that will affect total data presentation is visual acuity or the resolving power of the eye and the angle subtended by the display in relation to the user. The human eye can, in normal light, discriminate lines that are about 1.5 minutes of arc apart, using parallel black lines separated by intervals equal to line width (reference 2). This demonstrates an angular resolving power of 40 optical lines per degree. The angle subtended at the cornea by a viewed object is a further limitation on visual discrimination; this angle is $2 \arctan \frac{L}{2D}$ (where L is the size of viewed object measured at right angles to the line of sight, and D is the distance between eye and object). A flat display that subtends 50 degrees at the eye limits usable resolution to 2,000 optical lines. Inasmuch as resolution and the angle subtended limit the amount of information that can be perceived by an individual, the distance from display is not significant (i.e., a large display is not required in order to provide a large presentation). For a given viewing distance, display size must be increased if the amount of detail is to be increased (reference 3).

Assuming that a particular display presentation is designed to meet the human physiological requirements concerned with visual acuity and comprehension (or response to data presentation), display subsystems also vary in their respective update and request times.

Update Time

Update time is the period of time between acceptance of raw data by the system and display or storage acceptance of the processed information. This time frame may exceed the response times of the user and thus require storage until the user requests a presentation change.

Request Time

Request time is the period of time between request of presentation change and the actual change. This time frame varies greatly from system to system (mechanical systems have inherently longer request time than electronic systems). Request priorities may be programmed within the data processing system, thus forcing critical data into the display if information with lower priority is currently being displayed.

Presentation Characteristics

The characteristics of a particular display presentation are the form or quality of the presentation. The presentation form is the basic configuration (e.g., map or topographic presentation, pictorial, symbolic, or combination of these). Display presentation quality is affected by: resolution, contrast, distortion, accuracy, tone, and color.

Form of Presentation

Most military command and control systems require situation displays. This form of display normally uses a map background with superimposed supplementary data and less frequently uses other forms of topographic representation (such as aerial photographs or radar returns) as the background. These background data are tailored to the system and user requirements. The pictorial display may be either a stable one (as at a particular air defense sector) or a constantly changing display (e.g., of advancing army units).

Displays, other than pictorial, may be used to provide quantitative and qualitative data without graphical or pictorial referents (the referents, if required, are stated in map coordinates or coordinates of another "master" situation presentation). These displays may use alphanumeric characters, symbols which are meaningful to the particular user, various codes, and line drawings (such as graphs, and diagrams).

The display subsystem should be able to provide the majority of data classifications discussed, either on a single unit or on separate units where required. Frequently, the display uses a combination of situation and coded or symbolic data. The codes and symbols may indicate, qualitatively and quantitatively, the disposition of forces, equipment, and coincident operations of the enemy forces.

An example of a situation display is a presentation of the background of a tactical military map with line drawings representing national or military boundaries. Symbols and codes, indicating tactical units and their locations are superimposed, with alphanumeric notes providing detail and further description.

Information display requirements are normally included as part of the system design. The format is usually a formal, agreed-upon method of presenting all similar data within a particular system. This format should provide the data showing the various interactions, conflicts, and relationships (reference 3).

Quality of Presentation

The quality of the particular display presentation is made up of factors that most directly influence the absorption of information by the user. The design of good format, coding, and symbology will be completely negated if the user cannot perceive the amount of display detail needed to provide the information he requires. If the presentation quality is high, information that must be conveyed to the user in a given time frame may be increased. The factors determining presentation quality include: brightness and contrast, distortion and accuracy, color and tone, resolution and flicker.

Resolution, or visual acuity, has been previously discussed as an inhibiting factor in the amount of data displayed to the user. In general, resolution requirements need not exceed the resolving power of the eye. They are determined by a knowledge of the distance between user and display screen, the smallest display element which can be seen at this distance, presentation contrast, brightness, and clutter.

Display brightness depends upon the ambient light level within the viewing area. If possible, the average brightness at the display screen should be close to the ambient light level within the viewing area. Office lighting is optimally 100-150 foot candles. There are attendant technical difficulties in providing displays to equal this bright ambient level. Therefore, many viewing or display areas have extremely subdued lighting (approximately 30 foot candles) (reference 4).

Good display contrast is required so that various data appearing in the presentation are either "classed" or perceived with ease against the screen background (e.g., a bright or white spot against a dark background). Ideally, the contrast between the variable data (symbology) and the background (map) should be 30:1; the brighter levels may be required for those data which are most important to the user. Contrast may also be enhanced with the application of color variations. Classes of information, if shown in unique colors, can provide suitable contrasts. Inasmuch as perception varies among colors, all colors will not have the same brightness (in a physical sense) if they are to be seen as equally bright (in a psychological sense).

The flicker rate or critical fusion frequency (CFF) is an especially important consideration in regenerative type displays (such as CRT, photochromic, motion picture). The flicker rate is that frequency, usually stated in cycles per second, of alternating visible light pulses from which the human eye perceives a steady beam of light. This required frequency may vary from 2 to 60 cps, depending upon brightness, colors, total area viewed, light-dark ratio, surround brightness, and total exposure time. The CFF is normally low for low light intensities and high for high intensity light (reference 2).

Distortion of the display presentation must never be at such a level that the user must rely on interpretation of inherent distortion to obtain the needed information. Display distortion will cause the user to question the adequacy of the display and cause a restriction in the data flow. Distortion is ordinarily a technical design problem and must not be considered an inherent problem in all display systems.

Accuracy of a display presentation may be affected by display distortion. Determination of what degree of fidelity loss may be accepted depends upon system accuracy requirements. Accuracy is a dual consideration, involving subsystem accuracy (the data presentation should be a true representation of the data received from the processor) and system accuracy (the parameters under which raw data are processed for display). The system parameters usually limit or extend the amount of detail available for particular users. Excessive detail may be as debilitating to the system as limited detail.

Technology

The techniques and devices needed to implement the mobile display subsystem are not available in large variety. This may be attributed to present state-of-the-art, availability within the time period under consideration, and the diverse environmental and operational requirements demanded. The display subsystem techniques fall into two distinct categories: (1) those that use projected images (e.g., slide projector), and (2) those that are viewed directly (e.g., television or CRT). Projected systems, in general, are more sensitive to shock and vibration than are direct view systems because of the extensive use of optics in projection devices.

Projection Devices

Projection devices suitable for mobile use are classified as photographic, electronic, electrostatic, photochemical and electromechanical. Projection displays use two varieties of optical systems to accomplish enlarging, scanning, positioning and directing transmitted light; refraction (lenses), and reflection (mirrors).

Photographic

Photographic displays, in general, resemble slide projection systems. They normally use photosensitive emulsions (silver halide, Kalvar) to modulate light passing through the film, which in turn is controlled by optical projection devices. The most familiar photosensitive light modulator is the silver halide emulsion, usually used in conjunction with a transparent base. This film, sensitive to the visible portion of the electromagnetic spectrum, undergoes a chemical change on exposure. When processed (developed), the material becomes transparent, translucent or opaque, in proportion to the light variations to which the photosensitive emulsion was exposed. Intense light will cause opaqueness as the light value becomes less; transparency will increase. A bright CRT trace appears on the processed material as a black (opaque) trace against a transparent background: A reversal process is available to provide a bright trace against a dark background. This results in light values which resemble the original generating medium. Exposure of silver halide emulsions may occur in milliseconds; processing (especially two stage, negative to positive) is longer. As a rule of thumb, the faster the processing cycle, the poorer the resolution. If development (processing) time is about five seconds and advanced processing techniques are used, the resultant image may be 60 optical lines/mm with a maximum contrast ratio of 1000:1.

The Kalvar photosensitive emulsion differs radically from the silver halide emulsion both in sensitivity and processing. While the silver halide emulsion undergoes chemical changes, from both exposure and processing, the Kalvar emulsion undergoes electrostatic changes. The Kalvar emulsion is sensitive to a narrow band of the electromagnetic spectrum, peaking at 385 millimicrons (well into the ultraviolet). When exposed, a latent image composed of pressure centers within the emulsion is formed. When the emulsion is heated to approximately 290° F, the pressure centers form gas pockets several microns in diameter. When light is passed through this processed film, these bubbles cause light scatter rather than light absorption. Dark areas on the display screen are formed by the light scattering and not reaching the screen. Light areas on the emulsion pass the projection light without hindrance. Kalvar development, by heat, may occur in less than one second. The contrast ratio will be at least 25:1 with a resolution of 200 optical lines per millimeter.

Several devices are currently available which utilize these photographic techniques. They are similar in principle but differ in degree of automaticity, complexity, and request times. The simplest unit is the slide projector. A console version can take the form of a light box with an integral near projection screen, and one or more commercial 35- or 70-mm slide projectors. Each projector may have 10 slides in storage that may be selected automatically; the images from the projectors may also be superimposed.

Electronic

Photographic systems, with few exceptions, use exposures of cathode ray tube (CRT) traces to provide computer-generated data. The electronic systems normally utilize the CRT for direct display presentation.

Two electronic projection devices which will meet mobile display requirements are head mounted devices that, in effect, project the display directly into the iris. One device uses two 1-inch diameter CRT's (mounted on a helmet worn by the user) which project bright images, reflected by a series of mirrors, directly into the eye. This device can provide a three-dimensional display, inasmuch as a separate image is generated for each eye. The main disadvantage is the lack of extra-display vision, since the user can see only the display image. The second system uses a single CRT, which projects an image on a trichroic mirror. The trichroic mirror reflects a particular light bandwidth (green) and allows the remainder (red and blue) to pass through. This display presentation allows the user to view the external world while observing the current data, since this particular CRT trace projects green light which is reflected into the user's eyes (reference 5). The display appears as a magenta (blue and red) background, superimposed with green data. The trichroic system is also available as a "window" display with data superposition modes.

Schlieren Phenomenon

The Schlieren effect makes use of deformations within (or on) a transparent medium to refract light transmitted through the medium. The "Eidophor" control layer projector, for example, utilizes a version of this phenomenon. The effect depends upon line-light sources which, when uninterrupted, impinge upon a grid that is parallel to the light sources and are blocked by it. A transparent medium, with its associated ripples or deformations, when placed between the line-light source and the grid, will refract light through the grid and form light spots on a projection surface (reference 6).

Photochemical

Photochemical devices are similar, in some respects, to the photographic systems; both use light modulation and normally require projection. The photochemical devices use emulsions composed of light-sensitive dyes applied to a transparent medium. This family of dyes is generally referred to as photochromic; they are sensitive to varied light bandwidths. In their normal (unexposed) state, the dyes are transparent. When exposed to their critical light frequency, they become opaque and translucent in proportion to light intensity without processing (this change may occur in microseconds). The image may persist from microseconds to hours, depending upon the particular characteristics of the selected dyes. The photochromic emulsion can be exposed with a particular light bandwidth and projected with broad-bandwidth which has had the particular exposure frequency subtracted (references 7 and 8). The advantages of a photochemical system include: no processing delay, reusable material, possibilities of dynamic real-time display, color, and relative simplicity. There are a number of disadvantages including: the available material, being proprietary, is only available to the developing company; aging of photochromic media occurs as the number of exposures increases, causing the material to be replaced at various intervals.

Electromechanical

Electromechanical projection devices, suitable for mobile purposes, are basically variations of the x, y mechanical plotter. A line image is formed by scribing a line on an opaque coating deposited on a transparent medium. Light is projected through the scribed line and conventionally projected for viewing. The recording medium is normally replaced when the track or data are complete, or when the slide is cluttered with obsolete data. The slide cannot be erased. Color can be provided by the use of subtractive filters or color additive techniques. Multiple projectors which will superimpose a number of images and provide display continuity or classification can be utilized (reference 9).

Direct View Devices

Display subsystems, that do not rely on optical projection, are termed direct-view displays (e.g., television presentation). Most direct-view displays have a minimum of mechanical or optical components and are based upon use of the CRT.

Electromechanical

One device that may be classified as a direct-view display is the conventional, electromechanical x, y plotter. This device has been an off-the-shelf item for many years, and will not be discussed in detail. The plotter is relatively slow and can provide only limited detail. As detail requirements increase, weight and complexity of the plotter greatly increase.

Electronic

The efficient use of the CRT display depends greatly on the character-generating ability of the data processing system and on knowledge of the characteristics of the CRT used. A conventional CRT must have its presentation regenerated frequently enough to provide a stable non-flickering presentation. A standard CRT must have its presentation regenerated about 30 times per second; if the presentation contains 1,000 characters, the generation rate should exceed 30,000 characters per second.

The storage CRT has provisions that allow presentations to remain on the tube face for a given amount of time. These storage tubes normally differ structurally from standard tubes by their use of the storage grid and two electron guns (i.e., a writing gun and a flood gun).

Displays can be retained for periods of seconds to several days. Writing speeds may be in excess of 30,000 characters per second with a resolution of 240 TV lines, which is greatly inferior to resolutions possible with conventional tubes (525 TV lines), or high resolution systems (1,229 TV lines).

The shaped beam tube is an extremely useful CRT variation. This tube does not require use of the standard CRT writing methods (such as the Raster Scan or Dot Pattern). Instead, the electron beam is directed to a stencil matrix which shapes the beam to one of 64 to 128 characters. The shaped beam is then directed to the phosphor-coated faceplate. Two variations of the shaped beam tube are now available. One version utilizes two electron guns: one for character generation and display and the other for conventional TV scan. A second version uses an optical window to allow map projection on the tube face simultaneously with character display (reference 10). Other shaped beam tubes are available with storage capability.

Further variations of the basic CRT include: the three-gun color tube, the Aiken or flat tube, the Lawrence or single-gun color tube, the electrostatic printing tube, and a tube with very high ultraviolet output.

Design Approach

Specific Requirements

The particular preliminary requirements that this transportable display subsystem must meet include:

1. Multicolor map or graphical background.
2. Multicolor data overlays presenting volatile data.
3. Several individual display consoles.
4. Large screen (group) display.
5. Flexibility of equipment.
6. Availability, without extensive R&D, within one year.
7. Mobility.
8. Reliability.
9. Ease of maintenance.
10. Ability to present non-prepared materials (such as captured maps and aerial photos) in original color.
11. Ability to utilize 70-mm AMS map slides.
12. Ability to utilize 35-mm formats.
13. No chemical or water dependence.
14. Contrast in excess of 50:1.
15. Update in 30 seconds or less.
16. Request from hard storage within 15 seconds.

These preliminary requirements do not preclude adherence to those general requirements previously discussed (reference 11).

Tactical Display Subsystem Design

Specific Environments

Figure 1 illustrates a system design that will meet many of the display requirements for Mobile Tactical Operations Centers (reference 11). The main sections of the system are overlay generator, individual console, display pickup, electronic display projector, and projection screen.

The following system design shows alternate approaches for several of the subsystems; these approaches are not meant to indicate the only possible techniques, but those envisioned as having the most promise in the sense of ready implementation.

The overlay generator receives data from the system computer and produces overlays which contain volatile information. The overlays are optically superimposed over projected map images within the individual console.

The alternate approach utilizes a CRT console, driven by the computer, to pro-

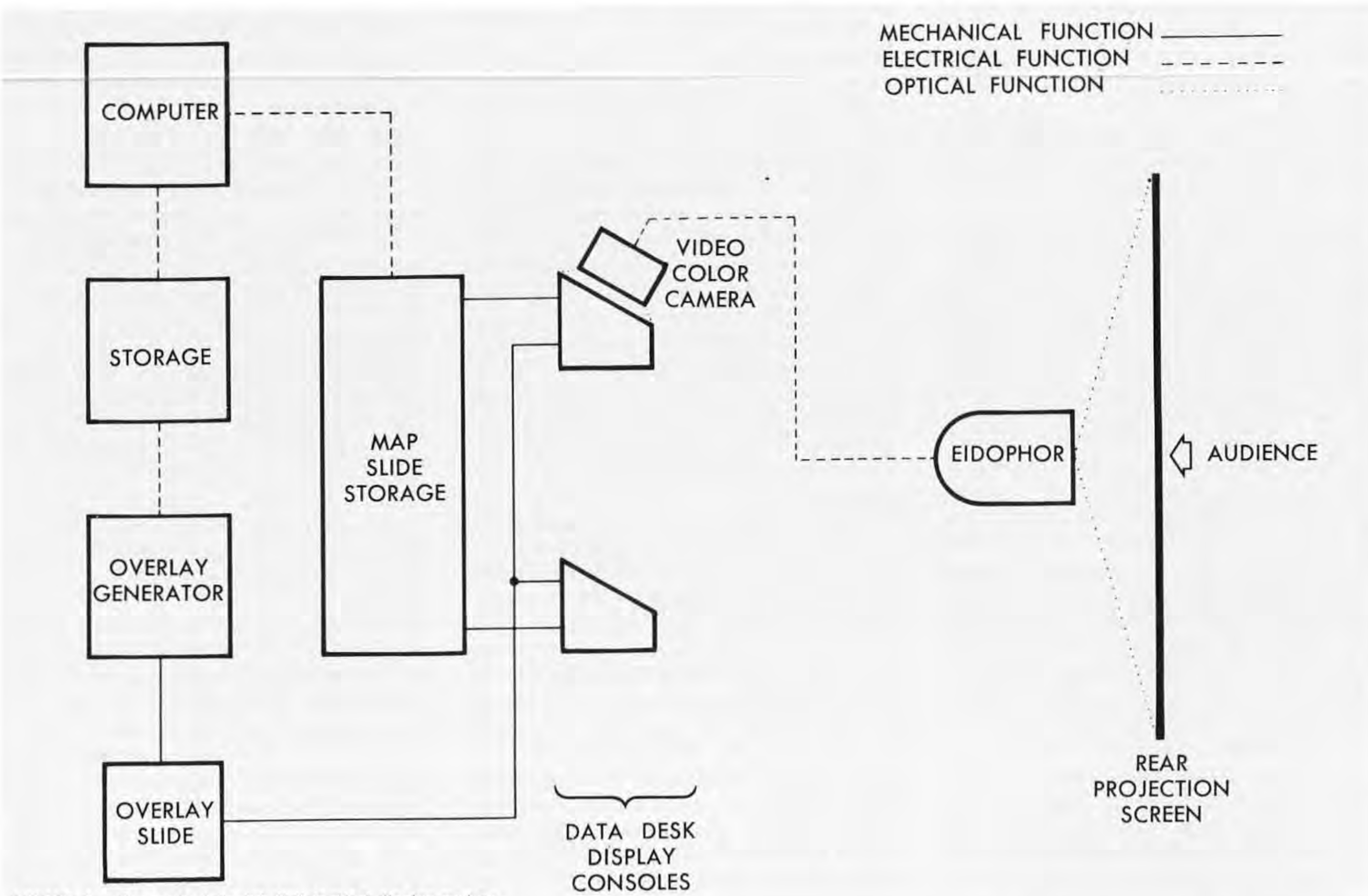


FIGURE 1: Conceptual "quick fix" tactical display system.

vide a display similar to the former, but lacking multicolor overlay capability. A video (image orthicon or vidicon) camera picks up the image appearing on either console and transmits it to the projector, which in turn projects this image to a front or rear projection screen.

Description of Overlay Generator

The basic components of the subsystem are as follows: miniature x, y plotter device (e.g., the Inconorama, Northrop's Vigicon, Kollsman's Datakrome), ultraviolet flash lamp, Kalvar diazo film, heat source, and associated film transport.

The system would operate as follows: Digital data from computer storage drives the x, y plotter which scribes through an opaque coating on a transparent medium, permitting light to pass through the transparent areas. A Kalvar ultraviolet film chip is juxtaposed to the scribed slide; a high intensity ultraviolet flash is activated which exposes the Kalvar chip. This Kalvar film chip is processed by exposing it to heat (240°F) via an IR source, or by passing it through heated rollers. The film is projected by a method similar to conventional photographic slide projection. In this case, due to the manner of exposure, the Kalvar chip is a negative (i.e., it will project dark lines against a white background). For a special Kalvar reversal film utilizing a projection overlay against a projected map background, a positive medium is required. The original Kalvar negative can become the master from which many Kalvar positives can be made. By passing ultraviolet light through the Kalvar master, the modulated light will expose as many overlay slides as required. The positive is fixed by heat in a manner identical to the master. These copies may then be transported (mechanically or automatically) to the data displays. Single Kalvar positive transparencies are obtainable with the use of a special emulsion and a pre-exposure technique (see below).

The plotter section of this generator is a production device which will require some modification to the optical light and slide handling sections.

It is possible to scribe a full (1- x 1-inch) slide in 250 milliseconds. Trace width of 0.13 $\pm$ 0.03 percent of full scale is possible. Positioning accuracy of stylus is $\pm$ 0.07 percent with repositioning at 0.03 percent.

The modifications to the plotter are as follows: utilization of an ultraviolet light source in place of broadband projection light, elimination of projection objective lens assembly, use of quartz lenses for condenser assembly, and the inclusion of a Kalvar storage transport and holding device.

An alternate approach would utilize the relatively new Kalvar direct image emulsion. This type of emulsion will provide a direct rather than reversed image from the source. The requirement for a master chip is negated at the expense of an additional light exposure and two heat exposures.

The Kalvar technology as discussed previously is based upon the phenomena associated with light scatter, reflection, and refraction. The Kalvar emulsion is sensitive to light in the near ultraviolet (3850A°). It is possible to expose the Kalvar emulsion at 0.01 seconds or less when the Kalvar has received 200 milliwatt-seconds/cm2 of actinic (incident) energy. This exposure to ultraviolet energy forms a latent image in the film emulsion and is developed by exposure to heat of 240°F to form microscopic "bubbles" (0.5 to 2 microns diameter) which in turn form the apparent projectable image (reference 1).

Alternative Overlay Generator Approach

An alternate overlay-generating device similar in many respects to those proposed by other system manufacturers (e.g., Litton, R-W, Hughes, and Philco) is described in the following paragraphs.

The character generation phase of the system drives a fiber-optic CRT with high ultraviolet output. A Kalvar chip is exposed by direct contact with the CRT processed, and can be used either as a negative master or as a direct positive.

The electromechanical technique (x, y plotter) offers rapid, intense image generation, low power and long life at the expense of complexity of imaging device. Further design tradeoffs will be generated when data concerning proprietary developments become available.

Several advantages and disadvantages are inherent in both approaches. The electronic (CRT-Kalvar) technique offers good reliability and image-producing simplicity at the expense of display generation complexity, high power requirements, and relatively short tube life.

Individual Display

Two variations of display consoles are presented here; one essentially photo-optical and the other electronic.

The photo-optical console is basically a light-tight housing containing multiple photographic projectors and rear projection screen. One projector is used for background display (a military map); the others project overlay or system generated data slides. The overlays may be colored-coded by the use of subtractive optical filters.

The projected images are superimposed upon the console screen producing varying brightnesses (30 to 100 feet-lamberts). To provide an 8- by 10-inch or larger display surface, folded optics must be employed to minimize total console size. The data desk has two functions: that of the individual console, and as the image input device to the group display system.

The alternate console design is based upon two variations of a shaped-beam tube. The first variation, incorporating two electron guns, can provide both variable line data (such as maps and graphs) and variable symbology (alphanumeric characters). One gun (as previously explained) is used in a TV (raster) scan, which can provide the variable background depending on the design of the associated storage, logic, and circuitry. The other gun, used in the standard shaped-beam mode, provides the variable symbology.

The second Charactron variation uses an optical window in back of the tube and parallel to the tube face (a light passing through the window will impinge on the tube face). An image, generated from a relatively simple slide projector, is placed on the face of the tube to form the presentation background (a line drawing or map) which

TABLE 1: Advantages versus disadvantages of photo-optical approach.

Advantages	Disadvantages
High resolution	Slow update
Multicolor background	Mechanical or manual
Multicolor overlay	Susceptible to shock
Simple to operate	Operability is dependent upon availability of film and processing chemicals
Simple to maintain	

TABLE 2: Advantages versus disadvantages of electronic approach.

Advantages	Disadvantages
Non-dependence on perishable materials (film)	Lack of multicolor overlays
Electronic (few moving parts)	Lower resolution (than photo optical)
Rapid update	More difficult to maintain in the field
High reliability compact	

can be imaged in full color (using color slide in projector). The shaped beam provides the variable symbolic data. Both methods employing the shaped-beam tube variations have interrelated requirements and disadvantages. The requirements are mainly concerned with the storage and circuitry necessary for rapid presentation regeneration.

The console approaches presented here are for two distinct areas: for the initial (lower echelon) center and for the advanced sophisticated system. The two types of consoles could be substituted in the system and still operate since the data processor program which drives the character generator could be used to drive the character generation section of the electronic console.

Certain advantages and disadvantages previously discussed are evidenced by the two console approaches; these are contrasted in tables 1 and 2.

Group Display Interface

To provide redundant and yet efficient use of equipment, a method is required to provide display generation capability to the individual displays. An interface device could be designed to convert binary data into a video scan mode for direct use by the group display projector. This device would use a scan conversion tube similar to those used by the FAA for bright radar presentations. The integration of stored map slide data into the display presentation may still pose a problem since the slide data must be either electronically transformed into signals for use by the group display projector, or projected separately to be combined with the computer generated data.

The solution proposed to provide group display generator capability makes use of a color video camera (image orthicons, vidicons or combination) or sequential color system to scan a console display and transmit the combined data directly to the group display projector.

The video camera must be capable of a broadcast quality presentation from luminance of approximately 50 foot candles of directed light at the subject, and be capable of color or monochromatic operation. This camera uses three image orthicon tubes (low velocity scanning beam and several stages of electron multiplication) and a vidicon tube (low velocity scanning of a charge-density pattern stored on a photoconductive surface). The image orthicons provide color channels, and the vidicon provides a monochromatic channel.

This subsystem allows the use of any display as a presentation generator for the group display projector. The video camera can also be used to pick up other display presentations (such as conventional maps or aerial photographs).

An alternative approach (figure 2) uses monochromatic video cameras. Monochromatic video cameras have the advantages of small size and high resolution. The video cameras would be used to scan copies of computer-generated overlay slides and transmit the data to the projector. Each camera would be responsible for a unique color (by control of bandwidth). The background could be supplied via a conventional optical photoslide projector.

Group Display

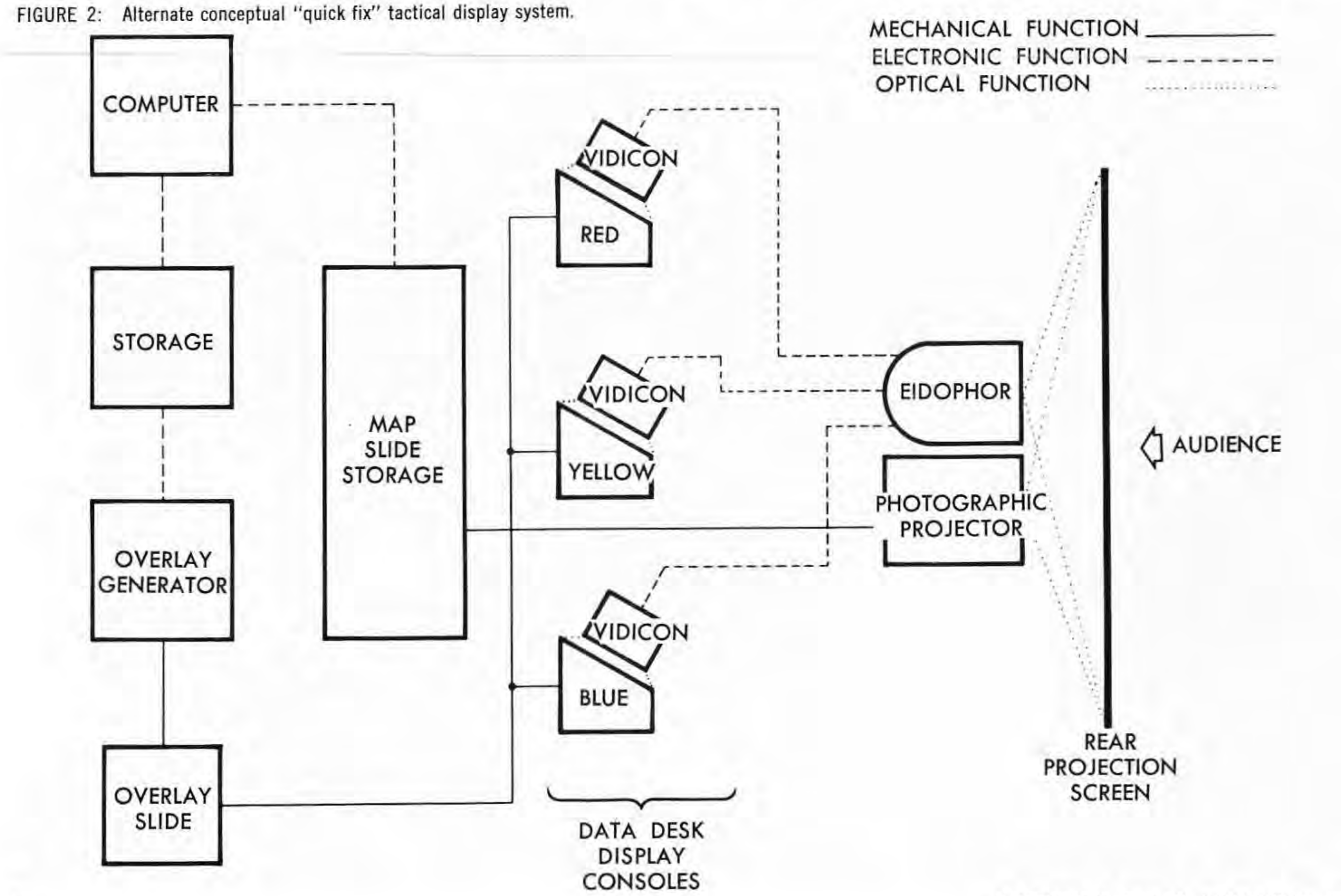
The group display is achieved by means of a color video pickup (e.g., vidicons) and a control layer or video projector such as the Eidophor or Dalto projector.

The video camera is positioned above the data desk and picks up the projected images, which are transmitted via cable to the projector.

The Ediophor control layer projector is not new (patents originated in 1939). The system allows a TV scan type display of large proportions (projection of an image as large as 24 by 32 feet) with brightness which is a function of a projection light source.

The Eidophor uses an oil film medium coated on a spherical mirror. The deformations are formed in the medium by electrostatic forces after an electron beam is focused upon it; in this case, reflected light is then refracted. Light that does not impinge on a ripple is

FIGURE 2: Alternate conceptual "quick fix" tactical display system.



reflected back to the source; light that impinges upon a ripple is refracted through the grid forming light images appearing on the projection surface, as indicated in figure 3. A detailed explanation of Eidophor operation may be found in reference 12.

Projection Screen

Generally speaking, there are two distinct varieties of display projection screens; front and rear. The front screen must be highly reflective (i.e., reflect projection source to its originating area where the audience is located); the rear screen must be highly transmissive (i.e., allow light images to pass through the screen to the viewing audience). Rear projection screens were selected for this system for several reasons; unobstructed view of display screen, efficient control of ambient light, efficient physical placement of projector and screen, and unobstructed light path between projector and screen.

To select a screen for this particular system, an approach advocated by Vlahos (reference 12) would be used. This approach considers nine selection factors.

1. Requisite screen brightness.
2. Ambient light.
3. Requisite contrast.
4. Screen reflection factor.
5. Screen gain.
6. Maximum bend angle.
7. Projection lens (focal length).
8. Requisite picture size.
9. Projector lumen output.

For example, the screen brightness must have suitable contrast within the ambient brightness of the display area. To determine screen brightness, the following equation may be used (reference 12):

$$\text{foot lamberts} = \frac{(\text{gain})\ (\text{lumens})}{\text{square feet}}$$

The contrast is the ratio of screen brightness to non-image brightness which is given by the product of ambient light and screen reflection factors. If the first eight factors are known, projector characteristics may be selected in terms of output in lumens (reference 12):

$$\text{lumens} = (\text{foot lamberts})\ (\text{square feet})$$

Since the success of this subsystem is greatly dependent upon the total presentation, the characteristics of the projection screen should be considered critical, and will depend upon the characteristics of the Eidophor and/or photo-optical projector.

Conclusion

The tactical command and control system has several characteristics that differ from the fixed base system, including mobility, variable environmental extremes, physical limitations on space, etc. These characteristics directly influence the choice of components and subsystems. The display subsystems must be meticulously selected, designed, and tested prior to field use. Several display techniques are readily adaptable to the rigors of field use and in turn can form the basis of several versatile, flexible display subsystems.

Appendix A

Functional Description of Eidophor Control Layer Projector (Figure 3).

Lenses (2) and (4) image light source (1) onto the slotted mirror (5), and in turn onto the spherical mirror (6). The slotted mirror (5) consists of several reflecting bars, and is also referred to as: bar system, grid, Schlieren lens, or raster.

Since the center of bar system (5) coincides with the center of curvature (M) of the spherical mirror (6), (5) is imaged in itself by (6). Light coming from each point of the illumination aperture (3) and falling on bar (a) is reflected towards the spherical mirror (6), and from there back towards bar (d) situated symmetrically with respect to (M). From bar (d), this light is reflected through the lens (4) in the direction of the aperture. The total light reflected from the mirror retraces the path it originally followed to the mirror from the light source.

Since none of the light reflected by the mirror escapes between the bars of the grid, the screen remains dark.

To illuminate the screen, it is necessary to divert part of the light returning to the bar system from the mirror. A thin layer (approximately 0.1 mm) of a viscous oil is uniformly spread on the concave surface of the mirror. If this oil layer shows no deformation, the light reflected by the mirror is not deflected and the screen will remain dark. If a small deformation is formed on the film, light will be deflected out of its original path of reflection and will pass between the slits in the bar system toward the objective lens which then images this spot onto the screen (reference 14).

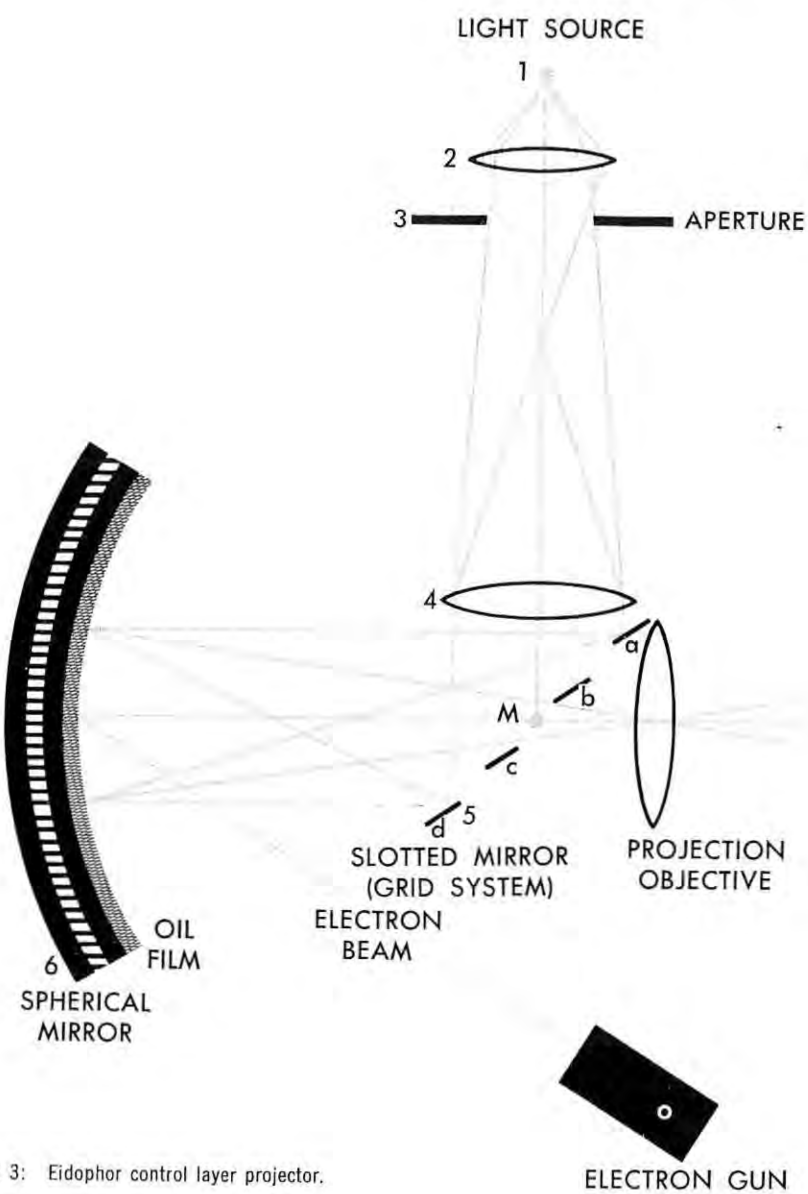


FIGURE 3: Eidophor control layer projector.

Appendix B

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Appendix C

A Short Glossary of Related Display Terminology

Achromat—(Achromatic lens). A lens designed to minimize chromatic aberration (distortion). The simplest form consists of two component lenses, one convergent, the other divergent, made of glasses having different dispersive powers, the ratio of their focal lengths being equal to the ratio of the dispersive powers.

Aperture—The diameter of the circular passage for light through a lens. The effect of the aperture is measured by the stop.

Aspheric—An optical element having one or both surfaces nonspherical.

Charactron—Trademark of a family of shaped beam CRT's manufactured by General Dynamics/Electronics and Stromberg-Carlson.

Collector—An optical device which collects or converges light waves.

Concave—Curved inward. (Concave lens — a divergent lens.) (Concave mirror — a curved surface, usually a portion of a sphere, the inner surface of which is a polished reflector. Such a mirror is capable of forming both real and virtual images.)

Condenser—A large lens or mirror used in an optical projecting system to collect light, radiated from the source, over a large solid angle, and to direct this light on to the object or transparency which is to be focused at a distance by a projection lens.

Convex—Curved outward. (Convex lens — a convergent.) (Convex mirror — a portion of a sphere of which the outer face is a polished reflecting surface. Such a mirror forms diminished virtual images of all objects in front of it.)

Diffraction—A small-scale spreading of light, beyond the limits of the geometrical shadow, which is observable when the source of light is small. At the edge of the shadow and parallel to it, a few alternately light and dark bands (diffraction fringes) are seen.

Dispersion—The variation of the refractive index of a substance with wavelength (or color) of the light. A prism may form a visible spectrum due to its dispersion of light. For most media, the refractive index increases as the wavelength decreases.

Eidophor—The trademark given the control layer television projector designed by CIBA; produced by Gretag of Switzerland.

Focal Length (of a lens)—The distance, measured along the principal axis, between the principal focus and the second principal point. In a thin lens, both principal points may be taken to coincide with the center of the lens.

Focal Point—The point at which parallel incident light (or radiation) is focused by a lens or mirror.

Lens—A portion of a homogeneous transparent medium bounded by spherical surfaces. Each of these surfaces may be convex, concave, or plane. If in passing through the lens a beam of light becomes more convergent or less divergent, the lens is said to be convergent or convex. If the opposite happens, the lens is said to be divergent or concave.

Light-Valve — Trademark given to the General Electric version of the original Eidophor design. This term is erroneously used to denote many nonphotographic light modulating techniques (e.g., applications of the Debye-Sears effect).

Objective—Those elements of an optional system which form the image.

Optical Resolution—Ability of a lens system to separate two entities (e.g., two points).

Optical System — (Refractive — When a ray of light passes from one medium to another it generally changes its direction and is said to be refracted or undergoes refraction.) (Reflective—Uses reflectors (mirrors) to focus light (radiation).) A reflecting system using a spherical mirror to collect and reflect light and correcting spherical aberration with a corrective lens (Schmidt) is the Schmidt mirror system.

Photographic Resolution—Number of discrete lines which are clearly defined on the emulsion as separate lines composing an image; usually denoted as lines per millimeter or inch (may range from 45/mm to limitations posed by film grain).

Spherical Aberration—A defect in the image formed by a lens or mirror having spherical surfaces, the spherical form being, in most cases, only an approximation to the ideal figure for the surfaces.

Television Resolution—The limiting resolution of the CRT is the maximum number of black and white lines distinguishable either vertically or horizontally. It can be measured by means of relatively simple test patterns such as the RETNA, resolution chart (1956). It should be recognized that the limiting resolution has, in general, little relation to the subjective sharpness of television images.

Television Horizontal Resolution — The number of light variations or picture elements along a line.

Microelectronic Character Generator Employed in Computer Display Processor

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Abstract

The paper describes a microelectronic character generator developed by Litton Industries' Data Systems Div., and its application in computer display processing. The hardware described had been functioning satisfactorily since February 1965 at the time of writing, and, based upon principles described, more advanced designs have been achieved and implemented.

Introduction

Cathode ray tube displays offer a real time, dynamic readout for digital computer driven command and control systems. A useful display should provide alphanumeric, symbol and line generation capabilities. In addition, the display operator should be able to communicate with the computer by means of a keyboard. A display processor with the above characteristics was designed and constructed by the Data Systems Division of Litton Industries. It is being used to demonstrate the Litton L-304 microminiature computer. Figure 1 shows a photograph of the Display Processor Console. Figure 2 shows the Processor with the microelectronic character generator drawers extended. Inside the console are the necessary amplifiers and power supplies.

Several unique design features are found in the microelectronic character generator. A digital character generation scheme is employed which uses only two different types of logic elements. The same packaging techniques and logic elements of the L-304 computer are used. This simplified the fabrication and helped reduce the unit's size. The complete character generator includes circuitry for the positioning and generation of alphanumerics, symbols, and lines, plus keyboard and I/O logic, all in one unit. A total volume of less than 100 cubic inches is occupied by the complete microelectronic character generator. The use of microelectronics allows a high degree of reliability with a mean time between failure in excess of 10,000 hours.

Aside from the microelectronic aspects, comparisons can be found with previous display systems. Usually, a separate character generator was employed for alphanumerics and symbols. A vector generator was used for line generation, and a separate register and D/A converter combination was used for positioning. Lissajous monoscope or stroke

FIGURE 1: Display console.

FIGURE 2: Display console with display processor drawers extended.

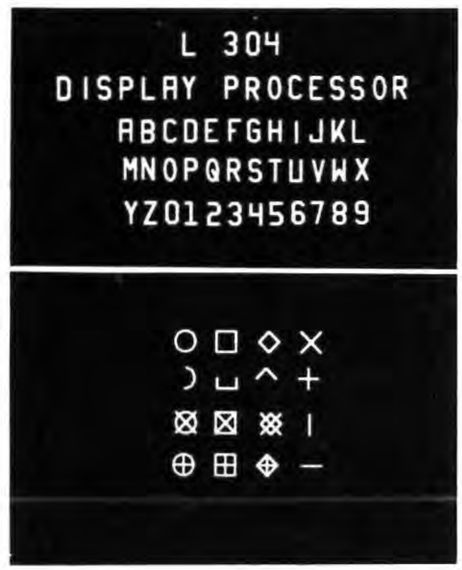


FIGURE 3: Alphanumerics and symbols.

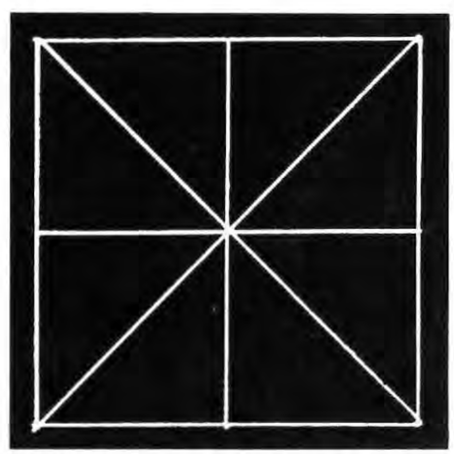


FIGURE 4: Square, normal line, slant line, and basic alphanumeric pattern.

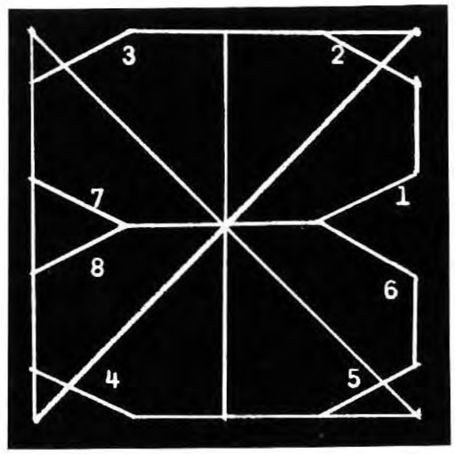


FIGURE 6: Chopped corner pattern combinations used in alphanumeric generation.

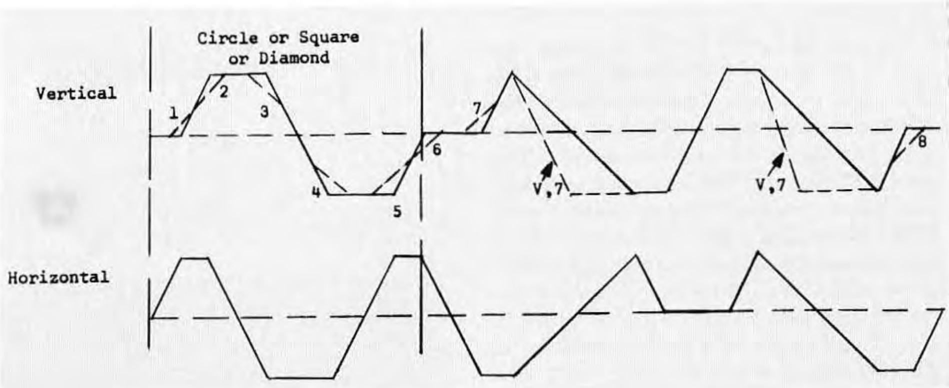


FIGURE 5: Vertical and horizontal deflection voltages used to produce Figure 4 or Figure 6.

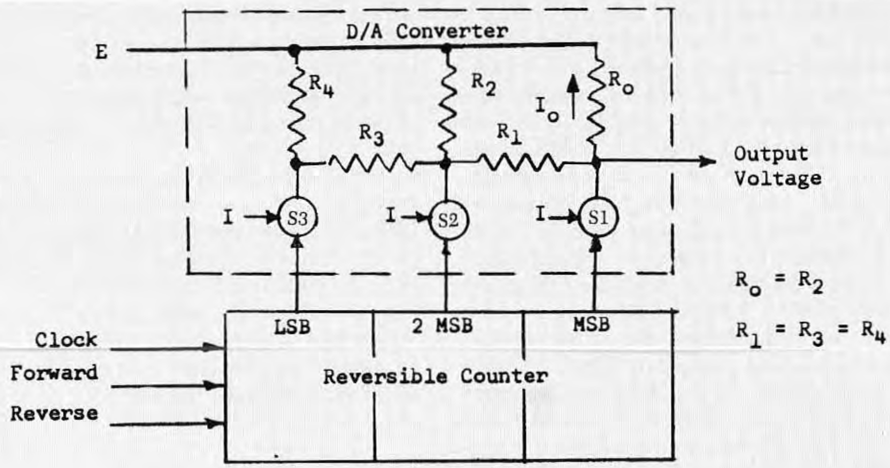


FIGURE 7a: Reversible counter driving D/A converter.

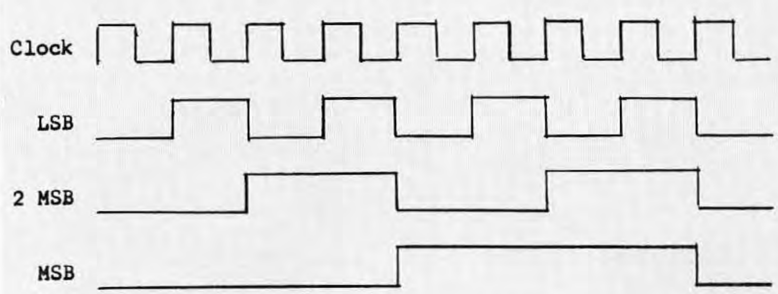


FIGURE 7b: Three bit counter output of Figure 7a.

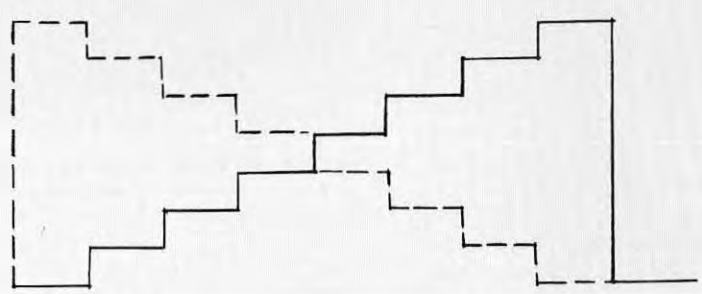


FIGURE 7c: Digilog output obtained from circuit of Figure 7a.

character generation methods have been used. These methods involve the use of special bulky packages or special (and long lead item) microelectronic circuits. From the standpoint of producing the smallest package possible, the above approaches were undesirable. Therefore, a Display Processor combining positioning, and character and line generation and using no special microelectronic circuits was developed.

In the design of the character generator, the packaging to a large extent determined the electronic configurations. That is, the equipment was designed with microelectronics in mind and this resulted in the extremely small package size. In fact, the unit is probably the smallest complete character generator available today.

When alphanumerics are generated on a cathode ray tube, horizontal and vertical deflection voltages as well as a CRT intensity control signal are required. Thus, 72 different pattern generation signals, plus intensity control signals, would be necessary for the 36 alphanumerics. However, if the same pattern is employed for more than one alphanumeric, and only the intensity control is changed to produce the desired alphanumeric, an appreciable simplification results. Also, if the symbol and alphanumeric generation are combined, a saving in hardware occurs (Figure 3).

Figure 4 shows the basic pattern which could be used to display a square, normal lines, and slant lines by merely intensifying the elements of the pattern desired. The identical pattern could be used to develop the A, E, F, H, I, J, K, L, M, N, T, U, W, X, Y, Z, 1, and 4. Figure 4 shows, in solid lines, the horizontal and vertical deflection voltages used for the pattern mentioned above. The remaining alphanumerics do not readily lend themselves to the pattern of Figure 4, either from an aesthetic viewpoint or due to ambiguities. If this same patern is used for the B and 8, the S and 5, O, D, and Ø, ambiguity results. This gives rise to a simple scheme to overcome some of the objections to the pattern of Figure 4. If various corners of Figure 4 are chopped as shown in Figure 6, then most of the rest of alphanumerics can be accommodated. The dotted lines of Figure 5 show what would have to be altered on the original vertical deflection voltage to chop all the corners shown in Figure 4. In actuality, different combinations of chopped corners are used, and the horizontal deflection signal remains unchanged. Four alphanumeric groups are thus obtained; they are: B, P, R, 2, 5, and C, G, Ø, 9, and S, 3, 6, 8, and D. The modification of the vertical signal to obtain the V and 7 is designated in Figure 5; again no change in the horizontal signal is necessary. The only occasion when the horizontal signal need be altered for the alphanumerics, is to develop an 0 and a Q. Since the circle symbol is available anyway, its pattern is also used for the 0 and Q. Using this approach, there is a definite difference between the Ø and 0, that is, the Ø has a more squared off appearance. The time interval shown in Figure 5 designated Circle, or Square, or Diamond is where either the circle or diamond deflection voltages are generated in place of the voltage for the square. Thus, the normal and slant lines may be used in conjunction with either the circle, square or diamond. The circle and diamond require changes in the horizontal deflection voltage, however. The total number of unique patterns developed is eight for the vertical and three for the horizontal. These patterns are the only ones required for the complete repertoire of symbols and alphanumerics. Figure 6 shows a representation of the pattern combinations used in alphanumerics.

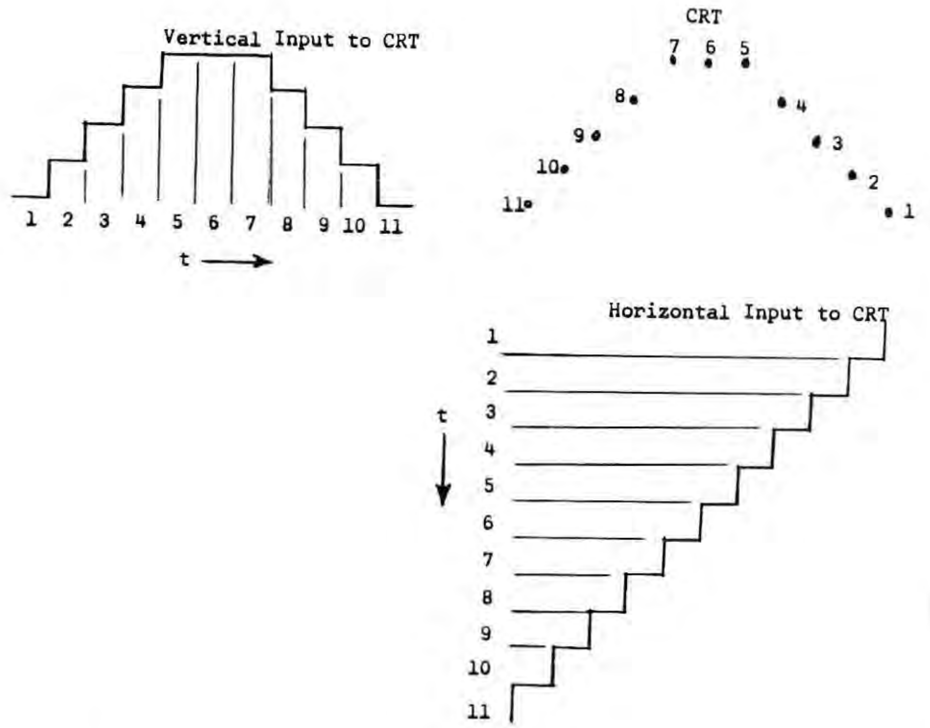


FIGURE 8: Horizontal and vertical inputs applied to CRT and resulting display.

Character Generation Principles

Character generation is accomplished by the programmable dot method. By placing the dots very close to each other, the elements of the pattern apear to be a continuous unbroken line. In this method, a reversible counter drives a D/A converter (Digilog), as shown in the example in Figure 7a. Each bit of the three bit counter is connected to a switch which turns on the current, I, when the counter bit goes positive. The output voltage of the D/A converter appears across R_0 and is equal to the product of I_0 and R_0. The current I_0 is equal to the summation of currents due to the condition of switches S1, S2, and S3, and the current, I.

If S1 is "on", a current of ½ flows in R_0, S2 produces a current ¼, and S3 causes a current ⅛. The division of current is determined by the resistance relationships between the resistors in the D/A ladder network. Thus, when the counter is counting in the forward direction, Figure 7b, the solid line Digilog output of 7c is obtained. If the counter were counting in the reverse direction, the counter outputs of 7b would be inverted, and the dashed line Digilog output of 7c would be obtained.

Figure 8 shows what a typical display would look like with horizontal and vertical signals applied to a cathode ray tube. The display appears as a series of dots since the CRT beam is stationary at each horizontal or vertical step. If the dots are placed very close to each other, they would appear to be solid lines.

Therefore, in order to generate various staircase ramps similar to Figure 7c, it is merely necessary to control the counting direction of the reversible counter as well as the number of steps to be moved. A typical example of this is shown in Figure 9. As can be seen, the reversible counter is told to go forward or reverse for a prescribed number of clock pulses by means of the control signals.

In order to develop alphanumerics or

symbols, it is necessary then to program the reversible counter in the pattern desired. Also, two different slopes of lines make it easier to develop all the characters. The slopes are derived by either moving the Digilog at one unit or half-unit increments. Thus, for the same number of clock pulses applied to the reversible counter, two different slopes may be obtained from the Digilog.

In order to give the alphanumerics a more pleasing appearance and to allow more letters to be written on a horizontal line on the CRT, the horizontal dimension of the alphanumeric is made one-half the vertical dimension. This is done by making the clock rate for the horizontal reversible counter equal to one-half the vertical reversible counter.

Display Processor Description

The character generator block diagram is shown in Figure 10. All the circuitry contained in the block diagram is housed in the compartment accessible from the front of the display console. This is shown in Figure 2. The deflection amplifiers, intensity control amplifiers, power supplies, and CRT circuits are composed of discrete components and are housed inside the display console.

The microelectronic character generator is composed of the following units:

Data Register

A 20 bit data register is employed to store computer information. Each bit of information is stored in a set-reset flip-flop. In between display times, the data register is reset. When the display is initiated, the register is activated, and the computer data is entered into the data register and held in storage during the display time. At the conclusion of the display, the data register is again reset.

International Control Logic

The internal control logic accepts inputs from the data register and combines the information logically. This produces signals which are used to control the pattern to be generated, as well as the CRT intensity. Separate control lines are obtained for various combinations of characters.

Display Clock

The display clock system furnishes the basic timing reference for the display timing counter, and is composed on a 4 mc. crystal oscillator plus a scale of eight Gray code counter. The Gray code counter yields sequential timing pulses

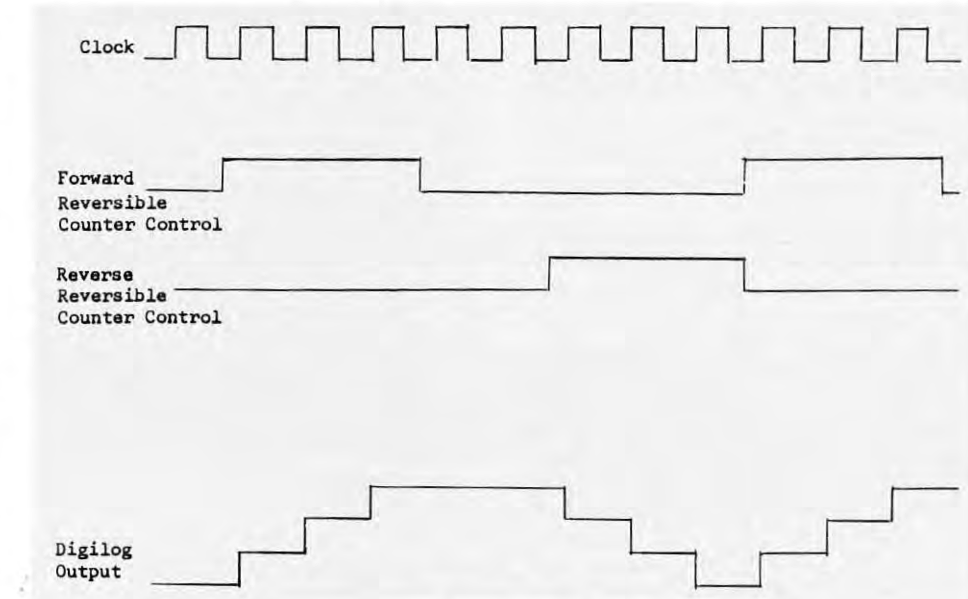


FIGURE 9: Forward and reverse control of pattern generator.

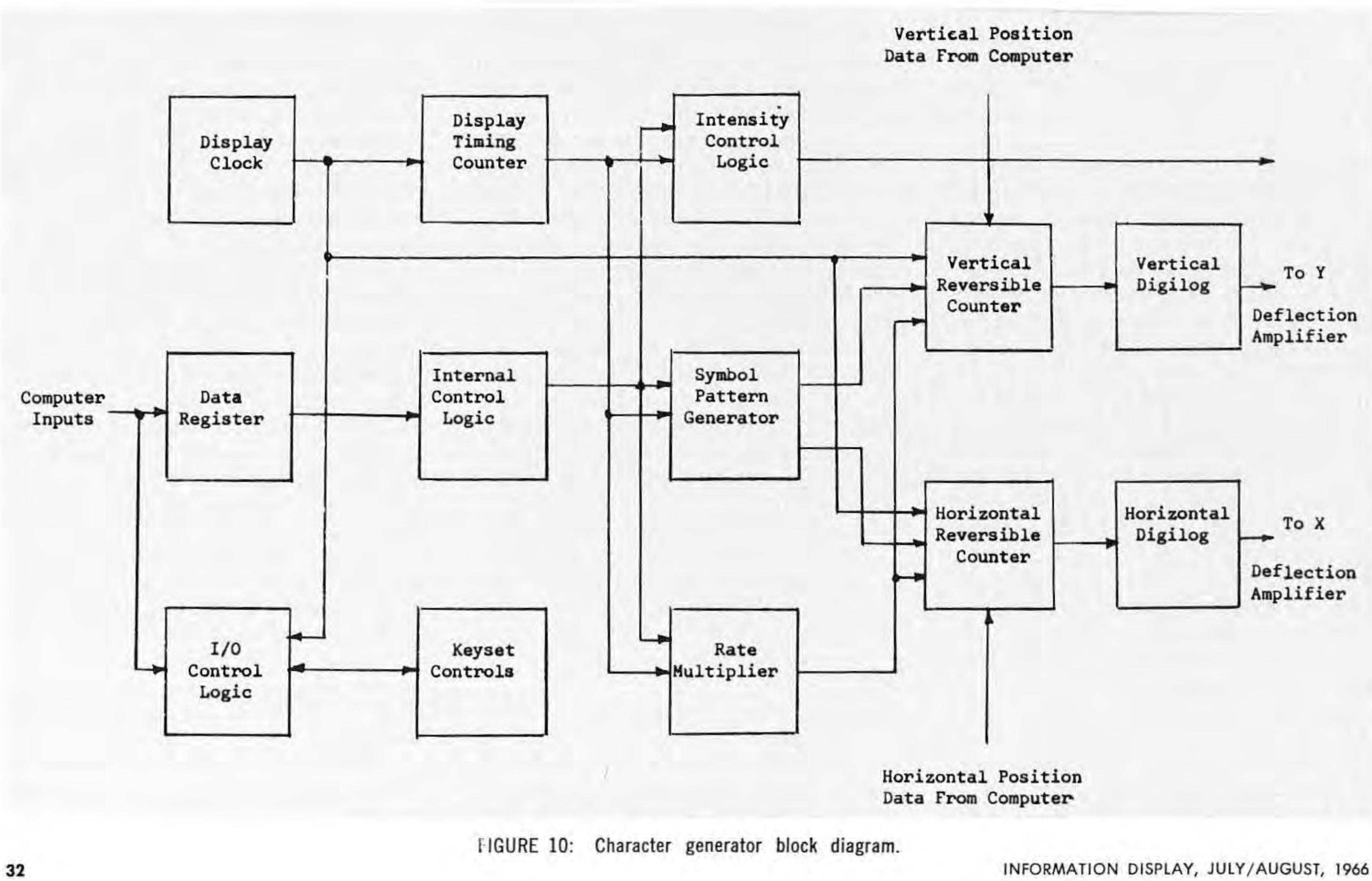


FIGURE 10: Character generator block diagram.

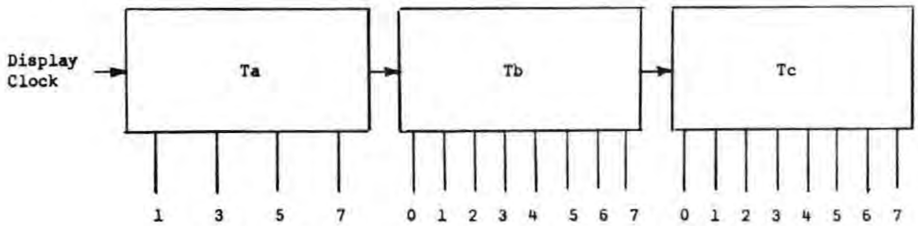


FIGURE 11: Block diagram display timing computer.

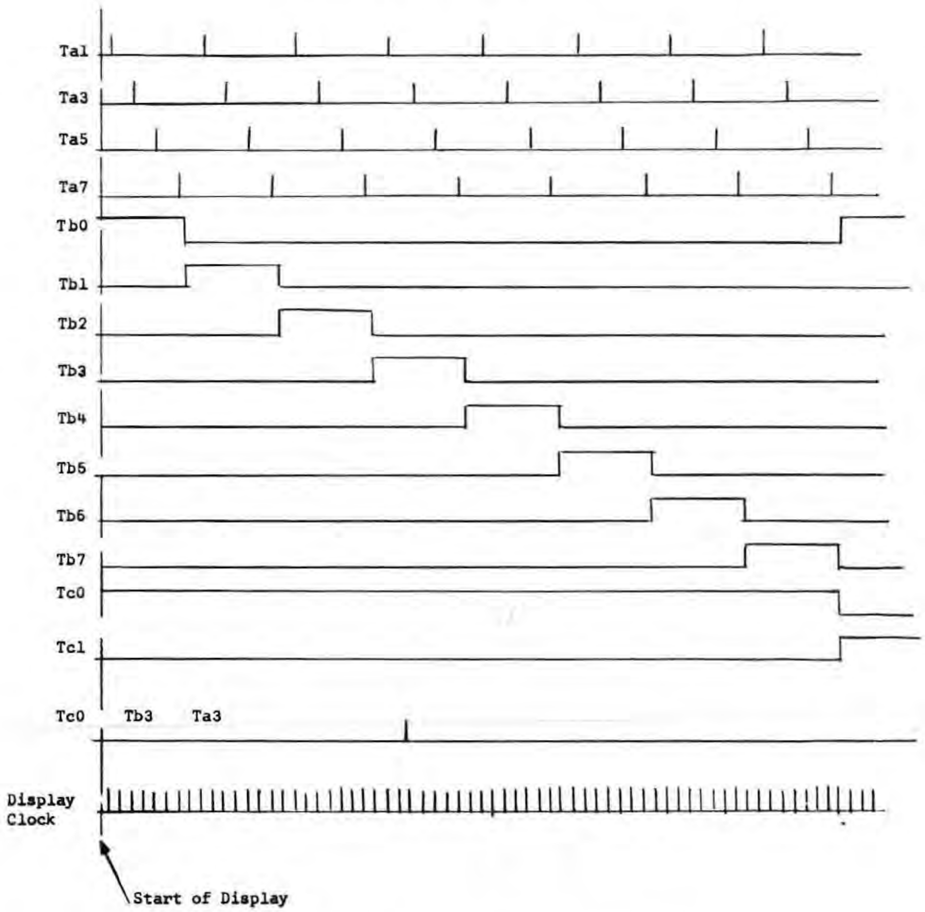


FIGURE 12: Timing diagram — Display timing counter.

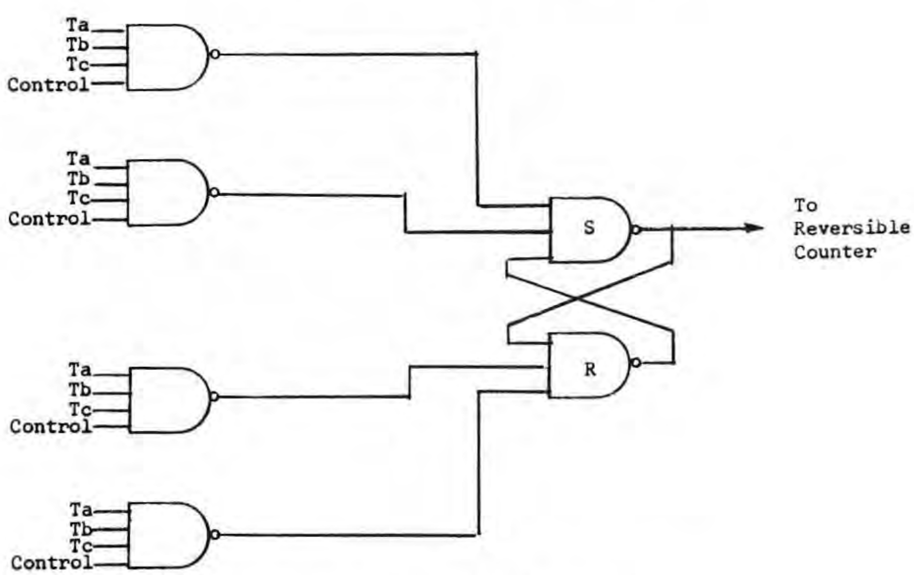


FIGURE 13: Typical control flip-flop.

used throughout the Display Processor.

Display Timing Counter

The timing counter is made up of three cascaded, scale of eight, Gray code counters driven by the display clock. It is shown in Figure 11. Each of these counters develop timing signals which are used to control the timing of the symbol pattern generator, the intensity control unit, and the I/O unit.

The timing diagram for the display timing counter is shown in Figure 12. Only four of the eight outputs available from Ta are required for character generation. For every Tb output, the four Ta pulses occur and for every Tc output, eight of the Tb outputs occur. The nomenclature is arranged so that the decimal equivalent of the octal number of Tc, Tb, and Ta corresponds to the display clock time referenced to the start of the display. The example at the bottom of Figure 12 shows how the 27th clock pulse may be obtained. The decimal number 27 equals 033 octally; therefore, Tc_0, Tb_3 and Ta_3 are "ANDed" to obtain clock pulse 27 from the start of the display.

Symbol Pattern Generator

The symbol pattern generator is used to produce control gates for the horizontal and reversible counters. The gates are derived from eight flip-flops, four are used for horizontal and a like number for the vertical reversible counter controls. Of the four flip-flops for each axis, two control the forward and reverse, unit increment steps of the Digilogs. The other two control the forward and reverse, half-unit increment steps. To develop any desired pattern, the eight control flip-flops must be set or reset at the proper times. This is done by inhibiting the clock going to the timing counter when no display is called for. When a display is initiated, the timing counter clock line is enabled, and the data register and internal control logic combine to produce a control line which is "true" for the desired character. At specific clock times, referenced to the start of the display timing counter, the control flip-flips are set or reset. The specific clock time is determined by decoding the proper outputs of the display timing counter.

Figure 13 shows a typical flip-flop arrangement; Ta, Tb and Tc are the three timing signals.

The logic required for a control flip-flop may be simplified if more than one character uses the same clock time to set or reset that flip-flop. The control lines for characters meeting the requirements are "ORed" together so that if any one of this group of characters is true, the flip-flop will operate. As an example, if the C, G, Ø and 9 were supposed to set the horizontal one unit forward flip-flop at clock time 15, the C, G, Ø and 9 control lines would be logically "ORed" to produce one control line. The combination of terms would be "ANDed" with the three timing counter signals which yield a clock time of 15. Thus, for the C, or G, or Ø or 9, the horizontal one unit forward flip-flop would be set at clock time 15.

Reversible Counter

The reversible counter is a nine bit dual rank type. The most significant six bits of the counter are preset at the beginning of the display according to the binary weighted position information received from the computer. Since the reversible counter is tied to its respective Digilog, the initial position of the pattern to be generated is obtained. The zero count condition of the counters corresponds to a position in the lower left-hand corner of the display and all positions are measured with respect to this point. Since six positioning bits are available, 64 positions for X and for Y are possible.

As mentioned previously, either slopes at unit or half-unit increments may be developed. This is done by disabling the least significant bit (l.s.b.) of the reversible counter when unit increments are required, and allowing the l.s.b. to operate when half-unit increments are desired.

Rate Multiplier

The rate multiplier is the unit used to generate lines. Binary weighted information is received describing the horizontal and vertical components of the line to be dawn. The △X and △Y components are generated, and the CRT output will then produce the vectoral sum of the components. The direction of the line is obtained by moving the horizontal and vertical reversible counters in either the forward or reverse direction. In this way, a line may be generated in any one of the four mathematical quandrants be merely choosing the direction of X and Y.

An example of a three bit rate multiplier is shown in Figure 14. The time relationship between the rate multiplier control signals and the reversible counter clock are shown. If a line weighting of six is called for, the reversible counter will move six increments and the Digilog output will appear as shown. With this three bit rate multiplier, up to a seven step line may be obtained. Since the lines are generated as a series of dots, these dots must be very close together in order to obtain smooth lines.

Intensity Control Logic

The intensity control logic controls the times when the CRT beam is intensified. One set-reset flip-flop is employed, which operates according to the symbol or alphanumeric desired. The time to set or reset this flip-flop is obtained by combining three timing signals from the display timing counter with the control line from the internal control logic calling for a particular character. This is the same method employed in the symbol pattern generator.

Digilog (Digital-Analog Converter)

Two nine bit Digilogs are employed (one for X and one for Y) to convert to X and Y position and symbol information from digital to analog form. Digital inputs are delivered by the reversible counters and the analog outputs are applied to the CRT deflection amplifiers. The Digilog switching time is much faster than the reversible counter clock time in order to minimize the effects of switching transients in the output of the Digilog.

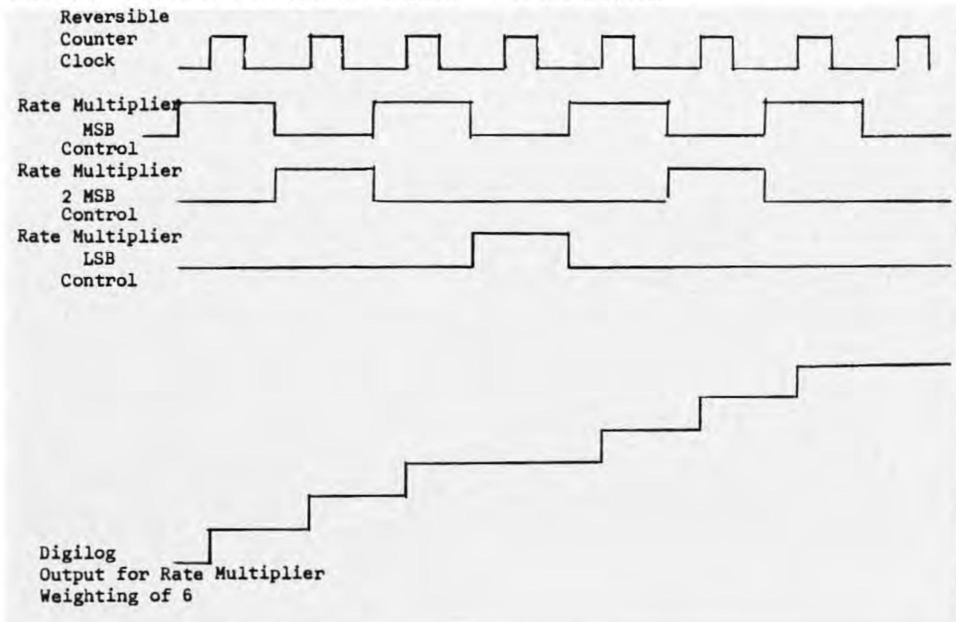


FIGURE 14: Three bit rate multiplier signals.

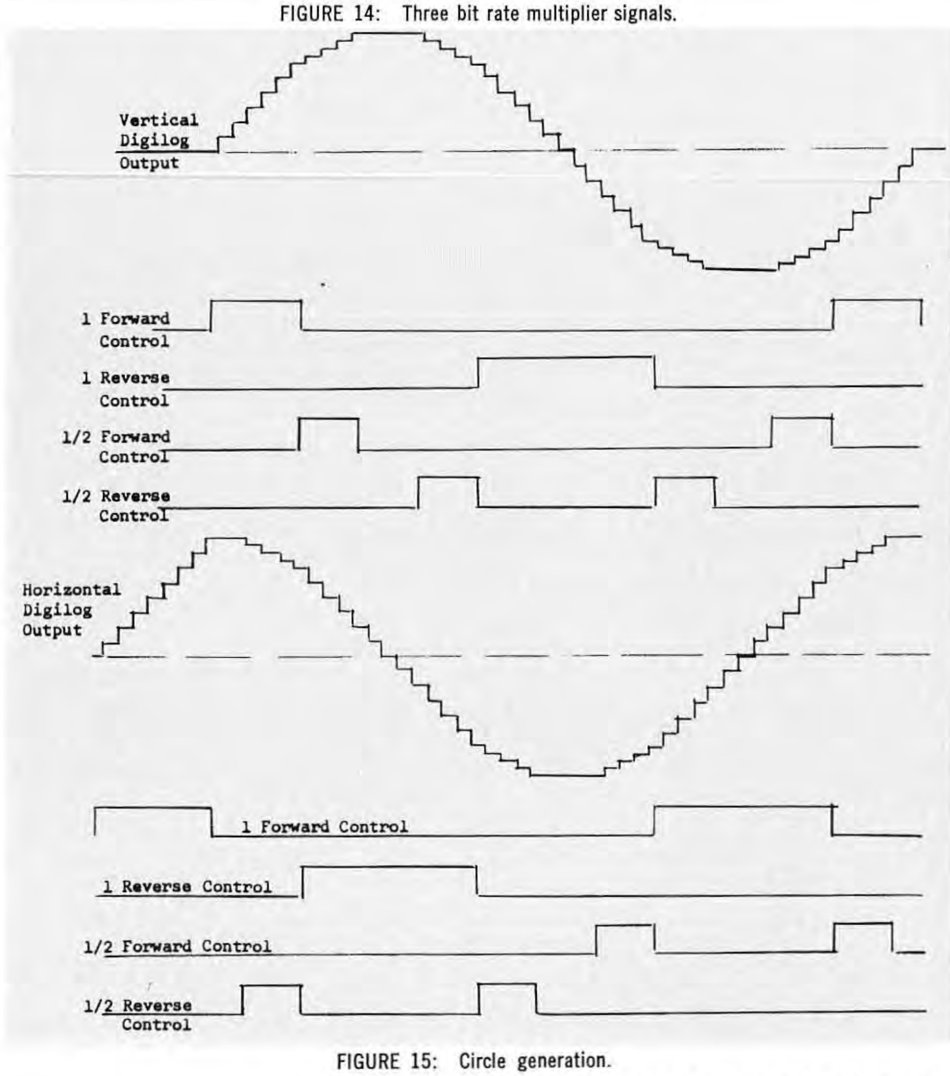


FIGURE 15: Circle generation.

To illustrate the functioning of the character generator the generation of a circle will be depicted. Figure 15 shows the control flip-flop and the Digilog outputs required to obtain the circle.

I/O Unit

The I/O unit performs three basic functions. It interprets computer and/or keyset commands. It initiates and/or controls the appropriate action in response to a command. Also it controls the start and stop of the display timing.

The following units are found inside the Display Processor Console and are composed of discrete components:

CRT Deflection Amplifiers

Two identical transistorized deflection amplifiers are provided for the horizontal and vertical deflection plates of the CRT.

The closed loop, small signal bandwidth of the amplifier is 4 mc. and is necessary to obtain good reproduction of display characters. Large signal response is not as critical since it only involves positioning of the character and 10 microseconds is allowed for this. The dynamic range of the amplifier is a 200 volt, differential output swing.

Intensity Control Amplifier

The intensity control amplifier derives its input from the intensity control unit and applies a 75 volt swing signal to the beam gating electrodes of the cathode ray tube.

Keyset Controls

In addition to a line power switch, the following switches are provided in the keyset. A momentary reset switch for reseting the Display Processor. Six alternate action pushbutton switches whose function is dependent on the computer program. A momentary data entry pushbutton which is used when information is to be entered into the computer. Four alternate action pushbutton switches are provided so that specific symbols may be deleted from the display if it is too cluttered with information. A thumbwheel switch is available for use with the six function switches. The track stick is associated with two pushbutton switches; one activates the track stick and the other causes the track stick information to be entered into the computer. The complete keyset arrangement is shown in Figure 1.

The logic elements used in the character generator are called Lincs, (Litton Nand/Nor Circuits). Figure 16 shows schematics of the types which are used, the dual four input and the single eight input gates.

Flatpac transistors are used in the digital to analog converters (Digilogs) and clock generator of the display. Microminiature resistor packages are used with the Digilogs. Two special RC networks, a crystal, and flatpac transistors are used in the clock generator. These are the only places where other than Lincs are used.

The character generator utilizes digital circuitry almost exclusively, and the only analog circuit is the resistive ladder used in digital-analog converters. Since the character generated could be almost fully described by logic equations, a computer can be used to check the logic. A program was devised which enabled an IBM 7090 to print out, dot-for-dot, all of the characters which could be generated. This eliminated virtually all logic errors.

Multilaminate construction is utilized in the character generator in a process developed by Litton Data Systems Division. (See Electronics Magazine, October 18, 1965, page 84; November 1, 1965, page 85, for details of construction). Two drawers are used, each consisting of a master laminate capable of holding 18 smaller laminates (patch panels). Each patch panel can hold 30 Lincs. Twenty-two patch panels are used, and these are not completely filled.

A total of about 500 Lincs and 33 flatpac transistors comprise the full complement of semiconductors. The character generator compartment in the display console is approximately 10 inches square by 1½ inches, and there is still room for an additional 500 Lincs.

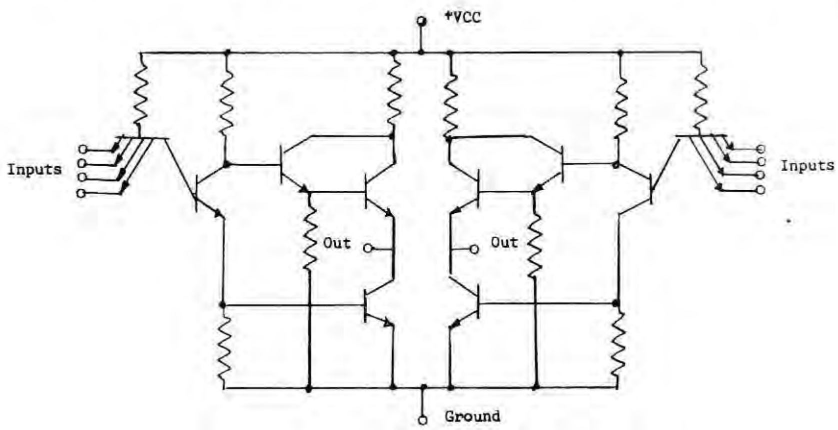
Since the display was completed, some newer microelectronic elements such as J-K flip-flops and Quad-2 input gates have become available. Using these newer devices and with some slight design modifications, a total of approximately 350 logic elements would be required for the complete character generator. Using the same packaging techniques as before, only about 50 cubic inches would be required for the new character generator.

Conclusions

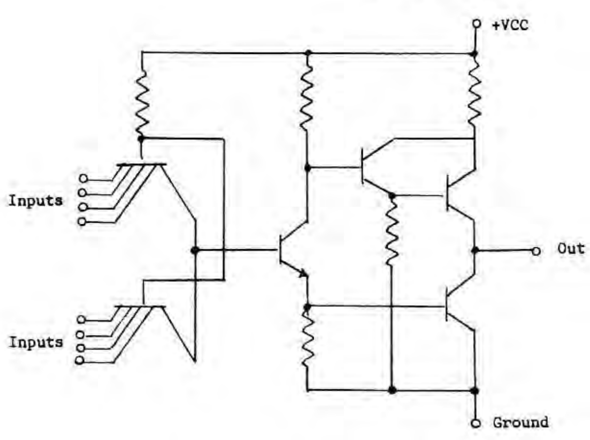
The Display Processor has met all its design goals and has been functioning in its packaged condition since February 1965. The design concepts developed on this program have led to further accomplishments in character generators. A newer high speed microelectronic version has been built which can generate alphanumerics in less than three microseconds average display time. Even at this faster rate, the appearance of the alphanumerics is better than the slower version.

Acknowledgment

I would like to acknowledge the assistance of those who worked on this project. F. R. Hultberg did much of the logic design and helped in the system design. Also, R. K. Marson designed the deflection amplifiers and some of the power supplies.



Dual Four Input Gate



Single Eight Input Gate

FIGURE 16: Logic elements (LINCS).

The Size and Contrast Of Hard-Copy Symbols

by A. C. Stocker

Displays Specialist
Systems Engineering Evaluation & Research Group
Radio Corporation of America

Abstract

This paper corrects an erroneous equation given in an earlier paper and provides experimental data on hard-copy symbols computed with the correct equation. The author argues that Blackwell's data on the visibility of a spot can be used to compute the optimum level of illumination for rooms in which both hard copy and self-luminous displays must be read.

Some time ago I published an article in this journal[1] suggesting a way to compute the optimum illumination for command centers and other rooms where both hard copy and self-luminous displays must be read. In that paper I used an erroneous expression for the contrast of hard copy. This paper corrects that error and provides data based on the correct expression.

This matter is important because at the present time the installation designer has no logical way to select the optimum level of illumination. The Illuminating Engineering Society publishes recommendations for the illumination of offices, but these are based on consideration of reflective materials only. It is well known that the visibility of reflective materials is always improved by higher levels of illumination, while that of self-luminous displays is always degraded, so such a one-sided consideration cannot yield the optimum value for a room in which both reflective and self-luminous materials must be read.

In the earlier paper I defined the optimum illumination as that which made symbols on the hard copy and on the self-luminous display equally visible, and I still feel this to be true. In that paper I used Blackwell's data on the visibility of a circular spot to relate the required exposure time to the size of detail, the background brightness, and the contrast of symbols, and this is open to question. There is no proof that Blackwell's data apply to the visibility of symbols. But certainly the visibility of symbols changes in the same direction, and hopefully it changes in about the same amount, as does the visibility of a spot when the size, brightness, or contrast are varied, and this permits us to make at least a rough comparison of the visibilities of the two types of materials. I therefore feel that the process is legitimate and that Blackwell's data will serve until the time when similarly complete data on the visibility of symbols become available.

In the earlier paper I defined the contrast of hard copy as the brightness difference divided by the lower brightness (that of the symbol). I should have realized that this could not be; the small fraction of the area covered by the ink can not have a controlling influence. Blackwell divides the brightness difference by the background brightness, and since I propose to use Blackwell's data, I shall use his definition. That is,

$$C = \frac{\Delta B}{B_0}$$

where C = contract,

ΔB = brightness difference between symbol and background

B_0 = background brightness.

In practice this equation takes two forms, depending on the kind of display picture that is being considered. When the picture consists of light symbols on a dark background, as is usually the case with electronic displays, we have the following:

$$C = \frac{B_s - B_0}{B_0}$$

where B_s = brightness of the symbol.

When the picture consists of dark symbols against a light background, as can be the case in television systems and is almost universally the case with hard copy, we have:

$$C = \frac{B_0 - B_s}{B_0}$$

And assuming, as is usually the case,

1 "Displays, Papers and Lighting", A. C. Stocker, *Inf. Disp.* Vol. 1, No. 1, Sept./Oct. 1964, P. 16.

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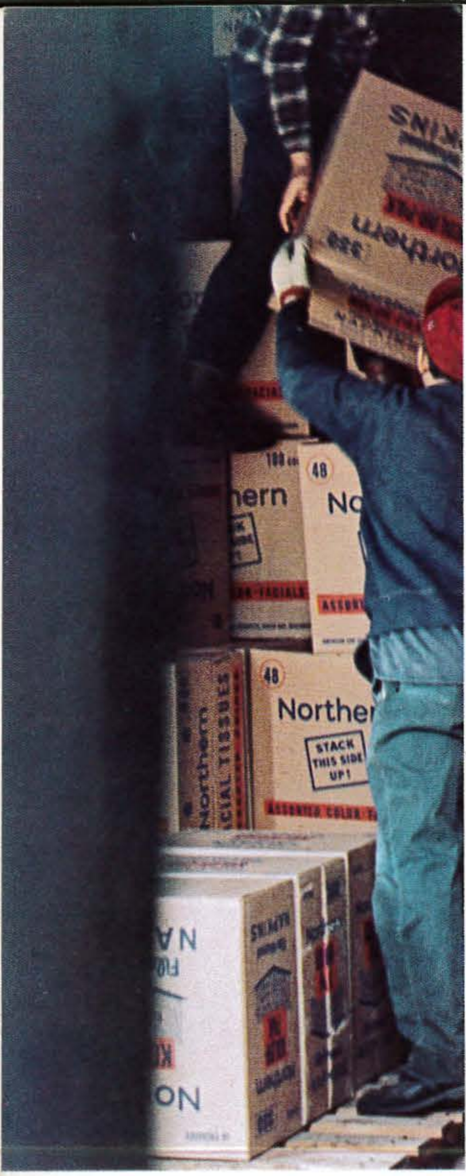
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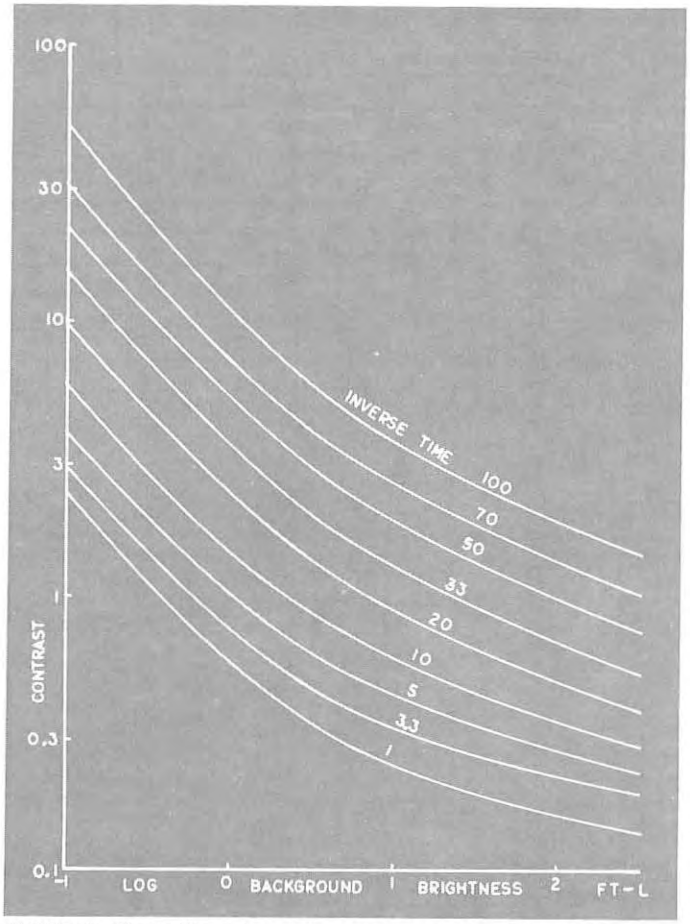

FIGURE 1: Blackwell's data on human performance, alpha equals one.

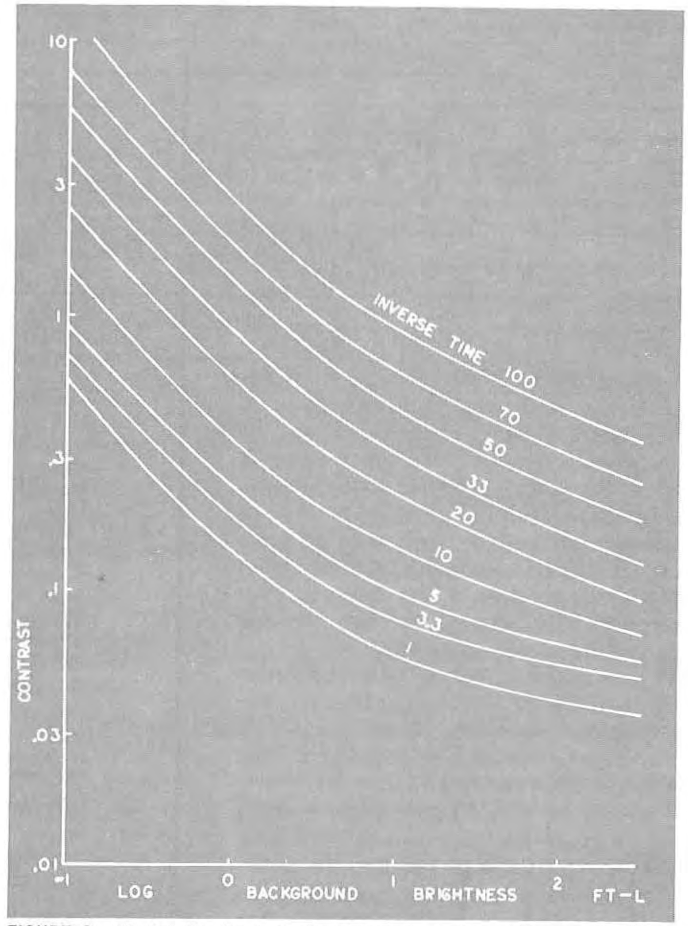

FIGURE 2: Blackwell's data on human performance, alpha equals two.

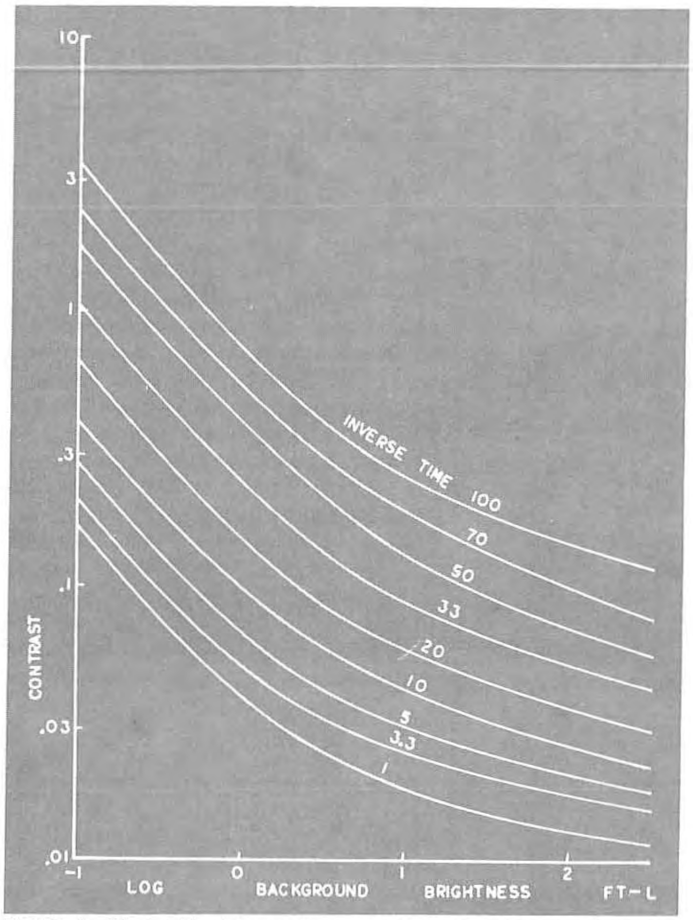

FIGURE 3: Blackwell's data on human performance, alpha equals four.

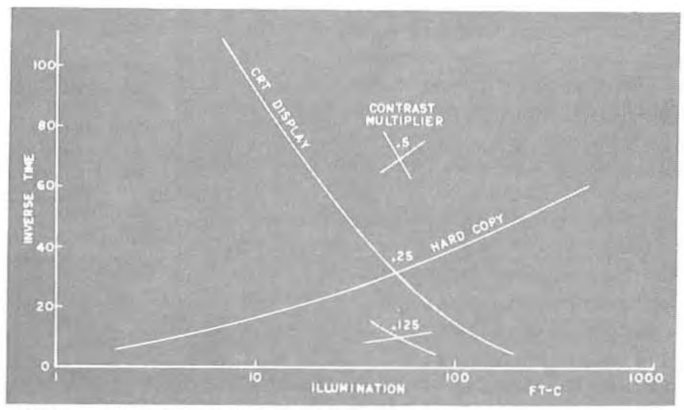

FIGURE 4: Selection of illumination.

that the illumination is constant over the area of the page, we can write for hard copy:

$$C = \frac{R_p - R_i}{R_p}$$

$$B_a = E_a R_p$$

where E_a = ambient illumination

R_p = reflectivity of the paper

R_i = reflectivity of the ink.

Since the table of contrasts of representative hard copy that was given in the original paper was based on the erroneous equation, its values were in error. Since the table had to be redone, a Munsell Neutral Value Scale was obtained and used to take more accurate data on the various values of reflectivity. Again the strokes of the symbols were magnified sufficiently through the use of a fifty-power microscope to permit an accurate comparison with the Scale. But because of the color difference, the reflectivity of wash-color backgrounds was largely a matter of judgement. The new data are given in Table 1.

It will be noted that all the contrast values given for hard copy are fractional. This will always be the case when dark symbols are presented on a lighter background, for it is not possible for anything to have a reflectivity less than zero.

The lower values of contrast in Table 1 make it awkward to use the curves of Blackwell's data given in the earlier paper, wherein the contrast had been multiplied by a "field factor" of forty. Figures 1, 2, and 3 show Blackwell's data with a field factor of unity. These curves may be used directly in many problems. It will occasionally be found that the parameters of a situation make it impossible to use these curves and plot the hard copy and the electronic display within the inverse-time range of 1 to 100. When this happens, one may multiply all the contrast values by such a factor as will permit plotting. This is merely a computational trick and has no affect on the selected value of illumination so long as the same factor is used for the complete computation for both the hard copy and the electronic display.

Figure 4 is a pair of curves for a representative pair of displays. It illustrates the fact that different contrast multipliers lead to the same value of illumination.

References

Stocker, A. C.: "Displays, Papers, and Lighting: The Visual System in Command Centers." *Information Display,* 1:1 (Oct. 1964) p. 16-26.

Blackwell, H.R.: "Development and Use of a Quantitative Method for Specification of Interior Illumination Levels on the Basis of Performance Data." *Illum. Engrg.,* 54:6 (June 1959) p. 317-53.

TABLE 1: Corrected characteristics of hard copy

ITEM	SYMBOLS				
	Height Mins. @ 16"	Stroke Mins. @ 16"	Color	R	C
Army Service Map					
Paper			white	.70	
Wash colors			green	.67	
			brown	.60	
Large letters	34	5.2	black	.09	.87
					.85
Small letters	10	1.9	black		ditto
Contour lines		1.1	tan	.30	
NOTE: R = Reflectivity, C = Contrast. For maps, the higher contrast is that of the symbol on white paper; the lower contrast is that of the symbol on the darker wash color.					
Sectional Air Chart					
Paper			white	.73	
Wash colors			green	.60	
Alt. above 12000'			brown	.40	
Large letters	24	4.3	black	.16	.78
					.60
Small letters	8.6	1.7	black		ditto
Scale tics		1.7	blue	.20	
Contour lines		1.9	tan	.35	
Air Force Chart					
Paper			white	.78	
Wash colors			green	.65	
			tan	.55	
Large letters	35	5.6	black	.09	.89
					.84
Small letters	9.5	2.2	black		ditto
Beacon names	13	2.8	blue	.20	
Maritime Chart					
Paper			white	.80	
Wash colors			tan	.75	
			gray	.70	
			blue	.75	
Large letters	31	3	black	.14	.83
					.80
Small letters	5.2	1.1	black		ditto
Compass rose tics		1.3	black		ditto
Geological Survey Map					
Paper			white	.75	
Wash color			green	.65	
Large letters	26	3.2	black	.09	.88
					.86
Small letters	9.7	1.5	black		ditto
Contours		1.1	tan	.25	
Typewriter Output					
Paper—good pulp			white	.75	
Electric—expendable ribbon	24	3.2	black	.10	.87
Manual—new ribbon	25	2.2	black	.09	.88
Manual—old ribbon	24	1.5	black	.16	.79
Teletype Printer Output					
Paper			tan	.70	
New machine & ribbon	23	4.3	black	.09	.87
Old machine & ribbon top		2.6	black	.16	.77
bottom			disappearing		
Computer Printer Output					
Papers, average			white	.72	
Supplier A	22	2.2	black	.12	.83
Supplier B	20	1.9	black	.09	.88
Supplier C	22	3.7	black	.12	.83
Office Copying Machines					
Supplier D					
paper—on white paper			white	.65	
paper—on black desk top			gray	.45	
print (on white)			brown	.18	.72
(on black)					.60
Supplier E					
paper (opaque)			white	.65	
print			black	.12	.81
Hand Written Material					
Paper—good pulp			white	.75	
Mechanical pencil .032" lead		5.4	black	.20	.73
Drawing pencil 2 H sharp		2.2	gray	.30	.60
Drawing pencil 2 H dull		3.2	gray	.30	.60
Wood pencil #2 sharp		2.2	black	.20	.73
Wood pencil #2 dull		6	black	.20	.73
Ball point pen, black, medium point		2.6	black	.18	.76
New York Times					
Paper			white	.68	
Print	16	2.2	black	.10	.85

Family of Computer-Controlled CRT Graphic Displays

Abstract

Graphic displays . . . man-machine interface . . . these were terms familiar to the military long before they found widespread use in industry. Pioneer work with SAGE, 412L, 465L and 473L laid the foundation for the current explosion of non-military applications. Computer Controlled CRT Displays provide a prime example of civilian industry benefiting from military developments.

[This paper was presented June 6, 1966, at the Armed Forces Communications and Electronics Assn. meeting in Washington, D.C., as part of a panel discussion entitled: "Visual Information Display Systems – A Critical Man-to-Machine Link".]

by Carl Machover

Information Displays Inc.
Mount Vernon, N.Y.

Introduction

I find it helpful to categorize display systems as shown in Figure 1. There are basically three types of systems:

1. Point-plotting
2. Alphanumeric, and
3. Graphic

For each type, there are three broad categories which can be characterized as:

1. Low-cost/low-performance
2. Medium-cost/medium-performance and
3. High-cost/high-performance.

The vertical axes of Figure 1 could have been skewed to emphasize that higher capability units tend to cost more than lower capability units with the same performance. That is, a low performance alphanumeric display will tend to be more expensive than a low performance point-plotting display. A rough indication of price range is also included in Figure 1.

As a further generalization, displays in the right-hand portion of Figure 1 tend to be evolved from military applications, while the displays in the left hand portion tend to be evolved from commercial developments. Frequently, the commercial display manufacturer attempts to upgrade the performance of his equipment for use in moderate military environments while the military display manufacturer tends to simplify his more sophisticated equipment in order to compete in the commercial market.

The shading in Figure 1 represents which categories of equipment are commercially available. As shown, equipment in almost all categories can be obtained as standard from some manufacturer. Two exceptions are low-cost/performance graphic displays and high-cost/performance alphanumeric displays. Low-cost/performance graphic units have a large potential market, but no equipment has yet been developed to fill this gap. High-cost/performance alphanumeric systems could be readily supplied, but there appears to be very little market for them.

Generally, not all companies supply equipment in all categories. For example, equipment available from Information Displays Inc. is indicated by the shaded area of Figure 2.

Typical applications for equipment in each category are shown in Figure 3. The tabulation is by no means inclusive, but does illustrate current usage. These applications will be discussed briefly, later.

General Characteristics

Consider next, typical block diagrams and performance characteristics for each of the categories shown in Figure 1. As shown in Figure 4, the output of the computer is digital, but the input to the CRT must be analog. Therefore, the overall system can be considered a digital-to-analog converter. Between the computer and the CRT are two blocks; (1) an Interface and (2) a Display Generator.

The Interface is a general requirement of most display systems, since it is probable that the input digital characteristics of the Display Generator

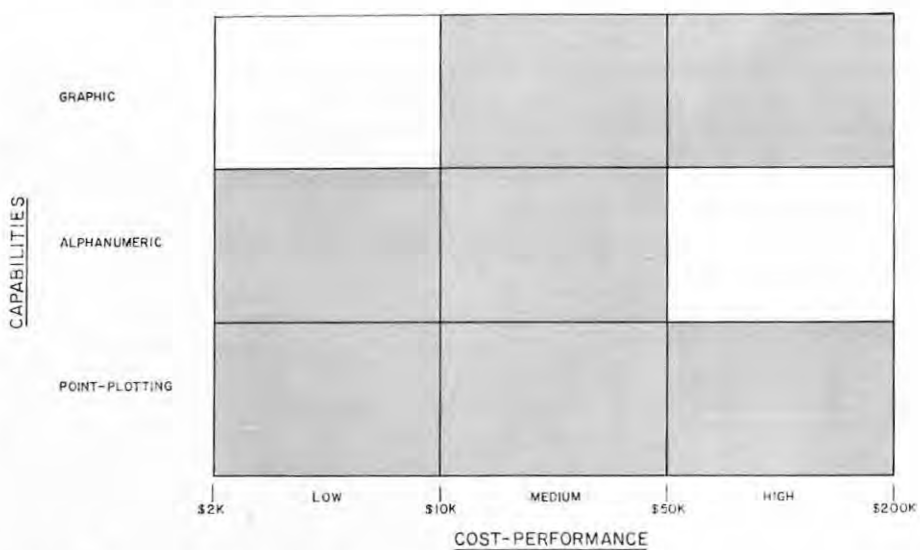

FIGURE 1: Commercially available CRT displays.

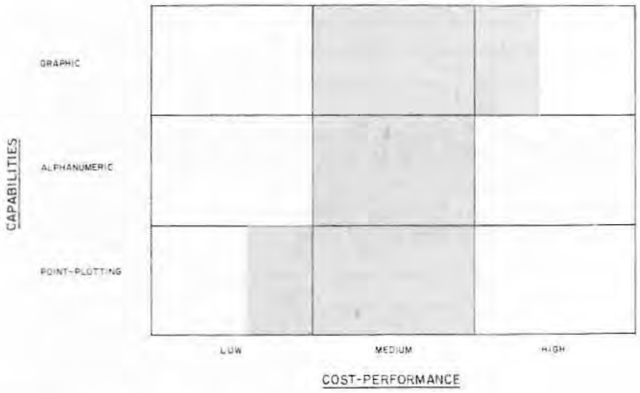

FIGURE 2: CRT displays available from IDI.

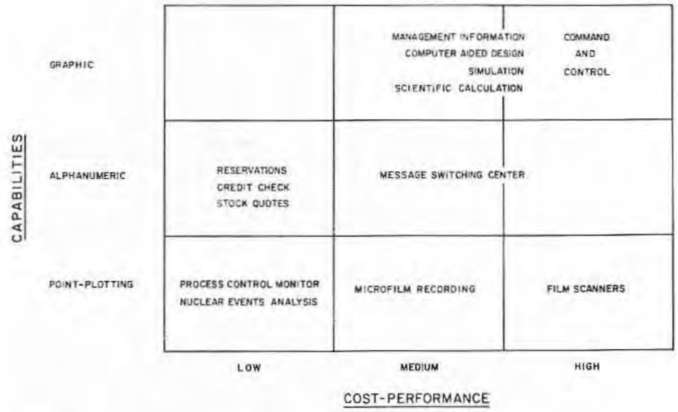

FIGURE 3: Typical applications.

are not identical to the output digital characteristics of the computer. Variations in word size and logic levels are commonly encountered. Also, as the same Display Generator will often be used in displays operated with several computers, the variation of communications with each computer must be accommodated. Some computers require a simple inquiry/response sequence, while others require a series of sequential signals between the computer and the display before data is transferred.

The Display Generator contains various function generators that convert the computer digital information into analog voltages for display on the CRT.

Commercially available systems use CRTs ranging in size from 5" round to 24" rectangular. The smaller CRTs are typically used for film recording, film scanning, and alphanumeric displays; while the larger CRTs are used for direct view consoles. Both electrostatically and electromagnetically deflected systems are used. Typically, the high precision, small diameter CRTs use magnetic deflection because of the smaller spot size and higher brightness possible. Larger CRTs also generally use magnetic deflection for the same reasons. However, there are large-screen (16"-19") electrostatically deflected tubes available.

When magnetic deflection is used, for the major deflection, often a second wide-bandwidth, small-angle deflection channel is added for character writing. This minor deflection channel is needed because the large-angle magnetic deflection systems have relatively low bandwidth. Both electrostatic and electromagnetic character writing channels are used in commercially available equipment.

Consider next, the detailed characteristics of each of the three categories of displays; that is, point-plotting, alphanumeric, and graphic.

Point-Plotting Display

A point-plotting display receives a digital instruction from the computer, containing the binary X and Y address to which the beam of the CRT should

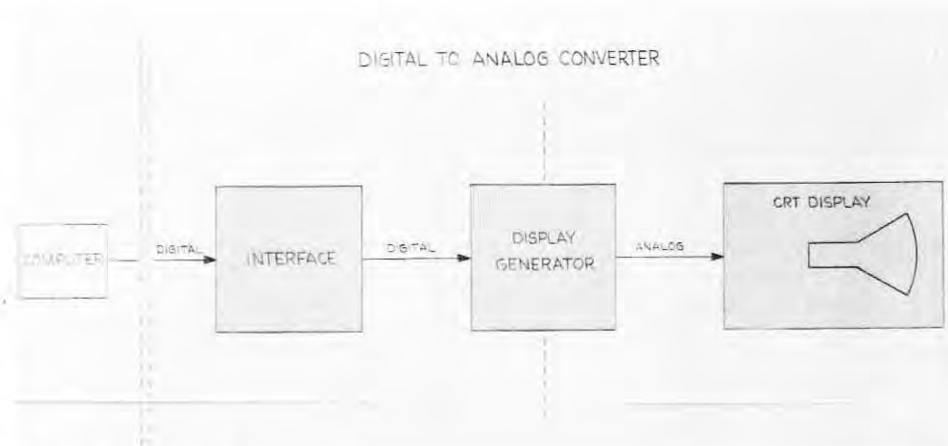

FIGURE 4: Generalized display system.

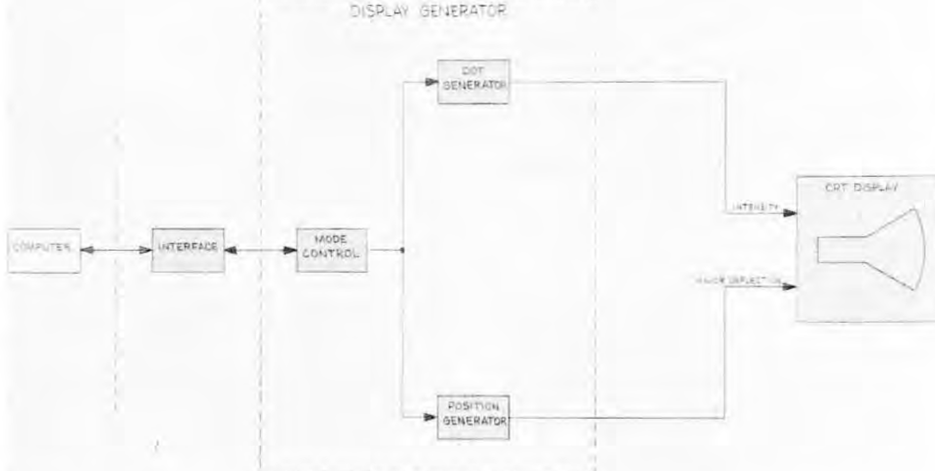

FIGURE 5: Point-plotting display.

be moved. Hardware in the display turns on the beam after it reaches the programmed position.

A simplified block diagram of a point-plotting system is shown in Figure 5.

Typically, the Display Generator is relatively simple. Only two functions are needed:

1. Position Generator, and
2. Dot Generator.

The Position Generator is a conventional digital-to-analog converter. Commercial systems usually provide 9-bit (512) or 10-bit (1024) X and Y positioning.

The Dot Generator is logic circuitry to turn on the CRT beam after a fixed time usually depending on the maximum time needed for the beam to reach the programmed position.

Generally, the Display Generator also includes a Mode Control. This is circuitry which decodes the computer instruction and activates the various function generators. In a point-plotting display, the Mode Control is relatively simple because there is usually only one function to be performed; plotting points. However, the system might be arranged to take advantage of the fact that points plotted at random across the screen may need more time than points plotted close together. In this case, the Mode Control would provide for two modes; random and incremental.

The ouput of the Position Generator is fed to the major deflection channel of the CRT, and the output of the dot generator is applied to the intensity channel. Random positioning time for magnetically deflected displays range from approximately 5 μ sec full scale to 100 μ sec full scale; while the random positioning time for electrostatically deflected systems is in the order of 5 μ sec full scale. With a typical full scale random positioning time of 14 μ sec, plus 2 μ sec for spot intensification, approximately 2100 dots can be displayed simultaneously at 30 frames/second.

FIGURE 6: Typical point-plotting (film recording) display.

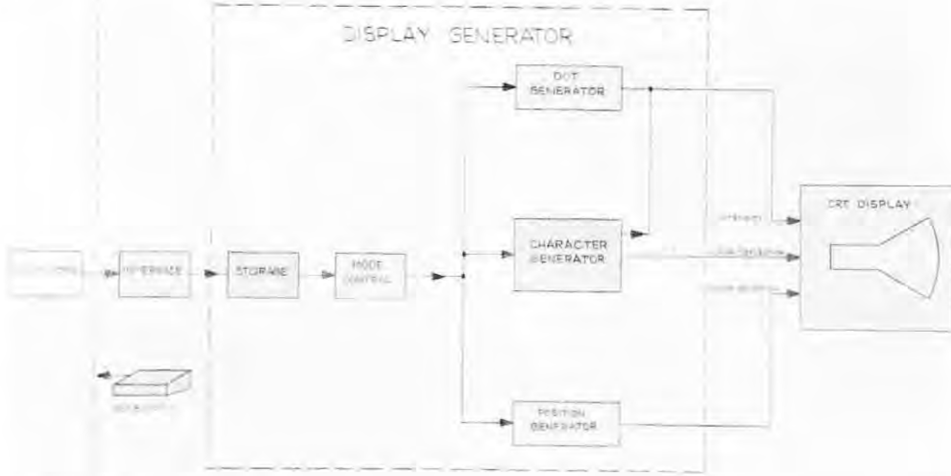

FIGURE 7: Alphanumeric display.

Low-cost/performance point plotting displays are often used in nuclear events analysis, to show relationships among several parameters. Resulting curves and surfaces provide meaningful information to the experimenter. Medium and High - cost / performance point - plotting displays are used in film recording. A typical film recording system is shown in Figure 6.

Alphanumeric Display

With proper software (programming), any kind of graphic presentation (such as characters, lines, and curves) can be formed as a series of plotted points. A total system represents a balance between computer software and display hardware. Because of the finite time required for each beam position and intensification, together with the large number of computer commands required for each character, it is often desirable to include several other function generators in the Display Generator to relieve the timing and computer programming problem. For example, the numeral "8" can be made with 17 dots. Therefore, if the display were to build up similar characters as a series of programmed dots, (assuming 15 μ sec/dot) only about 120 characters could be displayed simultaneously. This is generally inadequate for most applications.

Therefore, in an alphanumeric display system, another function generator, a Character Generator is added. See Figure 7. This is a device which accepts digital information about which character is to be displayed and generates analog deflection voltages for character tracing and intensification. There are some systems in which the character generator function is built into the CRT.

In the alphanumeric system, the Mode Control is more complex, activating either the position generator or the character generator, depending on which mode is programmed from the computer.

To relieve the updating requirements of the computer, the alphanumeric system might also include a Storage. The internal storage allows the computer to load the display with one frame of information and then the display is regenerated from the output of the store. No further computer action is required until the information is updated or changed. Typical alphanumeric systems use delay line storage, although cores, magnetic drums or discs can also be used effectively.

To provide communication between the display and the computer, a keyboard is often used. The operator can compose messages which:

1. are put into the store for checking before transmission, or
2. are transmitted to the computer directly and then displayed on the CRT.

Most low-cost alphanumeric systems use a raster presentation because one way to reduce the cost of a display is to use the equivalent of a TV monitor instead of a random point-plotter. These systems are very economical for producing text messages of from 200 to 1000 characters, but have extremely limited graphic (lines and curves) capability.

Random point-plotting displays are readily expanded from one level of capability to the next, (that is from point-plotting to alphanumeric to graphics). Raster type alphanumeric displays are special purpose units and are not, generally, capable of this expansion.

Commercially available alphanumeric displays, like those shown in Figure 8,

FIGURE 8: Typical alphanumeric displays.

are being used in many information retreival applications such as airline reservations, stock quotes, and credit checks.

Graphic Display

Systems capable of graphic presentations will have several additional function generators and various ways for modifying the generators outputs. This is illustrated in Figure 9. Vector (line) generators and circle generators are available. The time required to draw a full screen vector ranges from approximately 20 μ sec to 1500 μ sec depending on whether the line is drawn by analog techniques or as a series of incremented dots. The circle generator can draw circles up to full screen diameter from 100 to 300 μ sec, typically. Characters are written in from 2 μ sec to 100 μ sec.

A typical graphic display can present 2600 formatted characters, or 650 lines, or 325 circles, at 30 frames/second.

Also available in many computer controlled graphic displays are facilities for program control of character size, of symbol intensity, of symbol blinking and of line structure (so that the lines can be programmed as solid, dotted, dash-dotted or dashed).

As these various functions are added, the complexity of the Mode Control increases. This additional complexity results because of the greater number of control commands to be decoded by the Mode Control and because some special purpose display logic may be included. For example, the Mode Control may automatically increment characters across the screen, as in a typewriter mode – so that the Computer software need only stream out a series of character codes. Character spacing is automatically adjusted as a function of character size. At the end of a line, the string may be returned to the left hand margin, and decremented (functioning like the line feed on a typewriter). The Mode Control may also include provisions for stringing characters vertically instead of horizontally, and rotating characters by 90°. Rapid line drawing with minimum programming can be instrumented by providing a strung vector mode. After initial positioning, the Computer software need only provide new line end points, and the display hardware draws lines between the successive points.

The discussion thus far has been about a one-way device; information is received from the computer, converted in the display generator and presented on the display. However, one of the basic reasons for the increasing acceptance of graphic displays is the availability of an operator channel from the display back to the computer.

By using a light pen, track-ball, joy stick, Rand tablet, function keys, or other input device, the operator can converse with the computer on-line and in real-time. This powerful man-machine interchange is being used for computer-aided design, scientific calculations, program debugging, and simulation.

A typical graphic display is shown in Figure 10.

FIGURE 10: Typical graphic display.

In the higher performance graphic displays, central computer load is occasionally reduced by combining the functions of interface, storage, mode control and light pen tracking in a small digital computer. This computer is assigned exclusively to the display system.

In some applications it may be desirable for several display systems to be operating simultaneously, or that a record (hard copy) be made of the information being displayed, or that there be a wall size display for group viewing. Referring to Figure 9, these presentations can be driven from a common Display Generator through auxiliary line drivers. Deflection circuitry of all displays are driven in common, but the intensity circuits are gated in response to signals from the computer. For multiple viewing in several locations, the slave monitors can be standard displays, each with its own light pen and keyboard. If hard copies are required, one of the displays can be a small precision CRT viewed by a film camera. For group viewing, the monitor display can be either a high brightness CRT with conventional projection optics, or a scan converter feeding a TV projector.

Conclusion

Display usage is expanding rapidly. More frequently, the large computer is viewed simply as a utility – as a source of computing power available simultaneously to many users – much like the power companies use their generators and the telephone companies use their central exchanges. And the display is one device which will allow an individual to make use of this computer power.

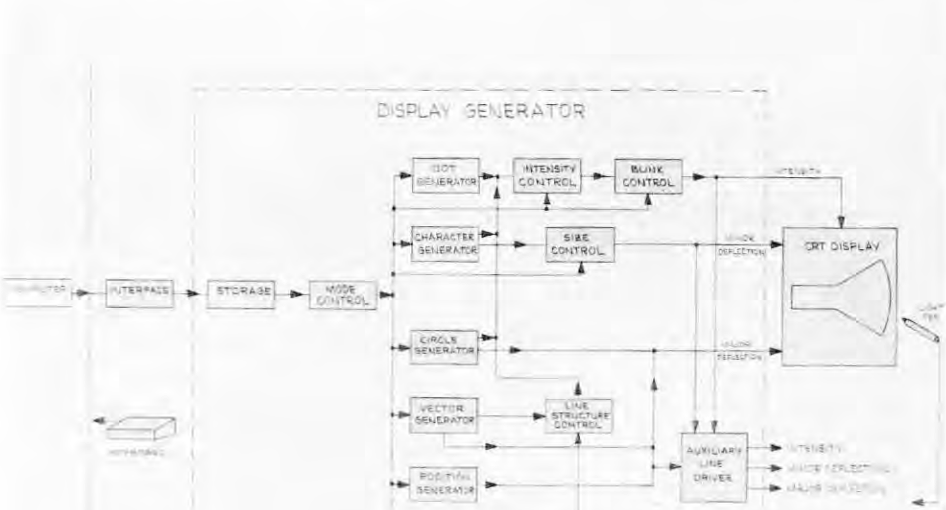

FIGURE 9: Graphic display.

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Dichroic Filters and Additive Color Displays

[This paper was presented during the 6th National Symposium on Information Display, *Society for Information Display*, Sept. 29-30, 1965, at New York's Commodore Hotel, and is republished here from the proceedings of that meeting.]

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Abstract

Large-scale displays for Air Force Command and Control systems commonly color-code displayed data. A repertory of seven codes is available through the technique of color addition, where dichroic filters split the white source into three primary colors, which are mixed on the screen to form color-mixture codes as well. The author investigated the effect of dichroic filters of different reflectances upon observer performance on the seven color codes. The object of the study was to define performance parameters on filters, a preliminary step to setting filter specifications.

Statistically significant differences between filters and between color codes were detected and analyzed. In the dichroic filter arrangement adopted, blue-red filter order, a blue filter reflecting wavelengths well into the green region facilitated performance in the majority of the color codes. A red filter close to the infrared in reflectance reduced performance in most codes. The most efficient color code, regardless of what filters were used, was red. Green, blue and cyan were the least efficient. Recommendations were made regarding options that would most likely lead to satisfactory seven-color coding for additive displays.

Introduction

Rome Air Development Center has recommended a film projection system at the group display chain that best meets the requirements of present-day Command and Control Systems.[1] Part of the recommendation and already incorporated into several major Command and Control Systems, *e.g.*, 425L (NORAD) and 465L (SACCS), is the capability for coding information in six colors plus white. This seven-color display involves dividing a single light source into three primary colors, red, green and blue, by the insertion into the light path of two dichroic filters (Figure 1) which reflect out the portions of the spectrum corresponding to two of the primaries while the remainder of the light forms the third primary. The primaries are then superimposed on the screen in various combinations to produce seven color codes: the primaries blue, red and green; magenta (red-blue), yellow (red-green), cyan (blue-green) and white (red-blue-green).

While much research has been done on color discrimination, most of it is peripheral to the practical problem of dichroic filter selection. The efficiency of color as a code depends fundamentally on the ability of the observer to discriminate color and the manner in which discrimination is required. Halsey[2] cited estimates of the total number of colors that can be distinguished as ranging from as high as ten million under optimal conditions to as low as three colors under minimal observation conditions and where strict speed and accuracy demands are made on the observer. Where absolute judgment is required, *i.e.*, where the observer must respond to each color with a unique name, a sample of investigators place the number discriminable at between six and twelve.[3, 4]

Several recommendations on color codes have been reported. These include the eight-, seven-, six- and five-color equally discriminable codes derived by Conover and Kraft[4] and the ten recommended filters or filter combinations producing high discrimination reported by Muller, Sidorsky, Slivinske, Alluisi, and Fitts.[5]

Unfortunately, these guides are of little value to the specific problems of additive color coding. The color codes produced in additive fashion must differ in brightness and saturation as well as hue. The discrimination task of the observer will vary from display to display in the real situation, as more or fewer codes appear simultaneously on the viewing screen. Hence, the observer's task will vary from relative judgment when all seven coding colors are present and a target color may be compared with six other codes, to an occasional rare instance when only one color occupies the display area and the observer must immediately and without mistake recognize the category of information that color code represents.

Little has been reported regarding specific differences between particular coding colors. From general color perception studies some information is available concerning particular colors. The cultural prepotency of red as an attractor of attention is a well-known phenomenon. Green and yellow are the brightest colors, while blue of equal energy appears dim, due to the nature of the response of the human retina. Jones,[6] in her summary of color research, noted generally reported differences between surface colors, with red being best for long-distance viewing, yellow the most efficient code over all conditions, and cyan leading to the greatest amount of variability from study to study.

The definition of efficiency of a color code appeared *prima facie* to have several discernible elements. The first, and the one of major concern in the research review above, is discriminability. A second factor is that of legibility, namely that the displayed information coded in a particular color must also be readable at a "normal" viewing distance. A third possible element may be related to attention-attracting, so that an observer is likely to take note the moment data coded in a particular color is displayed

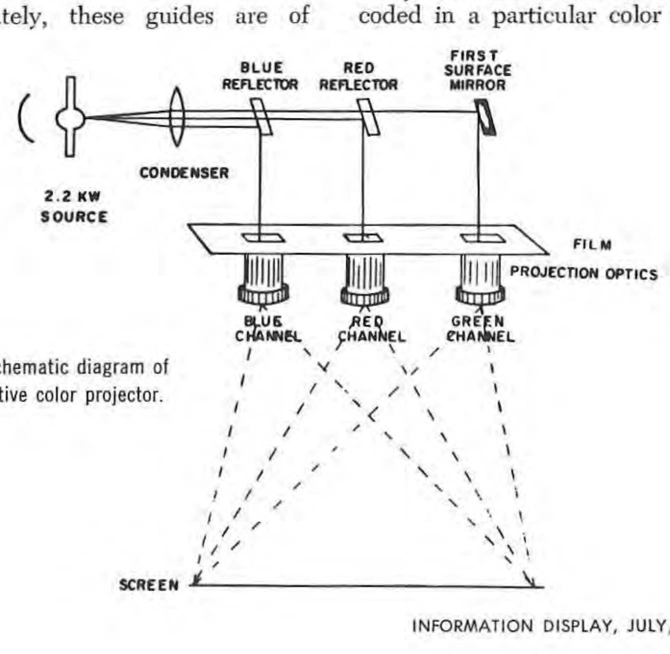

FIGURE 1: Schematic diagram of additive color projector.

and is able to pick information in the particular color from a multicolored format in the shortest possible time.

The present study explored the effects of various primaries in additively producing a seven-color code for observation in a large-scale display. The primaries were varied by exchanging the dichroic filters that partitioned the white light from the single projector lamp. The object of the investigation was to determine the most efficient dichroic filters for conditions similar to the operational case within the constraints of the type of task and light source employed.

Equipment and Experimental Technique

Display Equipment

A Colorvision 70 mm Additive Color projector with a 2.2 kw Hanovia xenon source generated the display. The projector was of a design similar to the 465L Strategic Air Command Control System model. Details on its operation may be found in the Colorvisioin projector manual.[7] The projector was powered by a Christie silicon rectifier, model HX-2500-28, with an auxiliary Lambda regulated power supply, model LT-1095, used to ignite the xenon source. A white Lux-Matte front projection screen, 6 · x 8 feet, was located 20 feet from the projection lenses to provide display surface.

A relatively short throw distance was imposed by the screen and room dimensions. To compensate for high display brightness which would ordinarily result under these conditions, a 1.0 log neutral density filter was inserted in the light path and the power to the xenon source was reduced from a normal operating load of 100 amps, 20-22 D.C. volts, to 50 amps, 16-18 D.C. volts.

A solenoid-operated shutter was installed in front of the projection lenses and activated by an Electra filtered D.C. power supply to control exposure time. Also part of the timing system were a Hunter timer, model 111A, a toggle switch control and a standard electric clock. The experimenter, E, initiated each trial by turning on a toggle switch which activated the timer and energized the solenoid, permitting the display to be projected onto the screen. At the end of a preset 15-second exposure, the timer circuit was automatically broken and the shutter closed. The clock verified the length of the exposure.

Filters

Dichroic filters are essentially glass substrates with chemical coatings that have the characteristic of reflecting some wavelengths while transmitting others. When placed at an angle in a light path, the reflected light forms one beam or channel, the transmitted light, another. For the investigation, six dichroic filters were selected, three blue reflectors and three red reflectors. The reflectance charactristics of the filters at the angle of incidence used in the projector optical assembly appear in Figure 2.

A common designation for dichroic filters is the point at which 50 percent reflectance is achieved. This 50 percent cutoff point will be used henceforth to refer to a particular filter. The 50 percent cutoff for the blue reflectors were approximately 491 $m\mu$, 498 $m\mu$ and 516 $m\mu$. For the red reflectors cutoffs were at 581 $m\mu$, 595 $m\mu$, and 619 $m\mu$.

The 498 blue and 595 red filters were supplied by the projector manufacturer, presumably selected for their compatibility with the data display. The other filters were obtained to explore the areas adjacent to the "standard" blue and red cutoffs.

Stimuli

Six randomizations of an alphanumeric matrix were programmed, generated on a Charactron tube, and photographed on Kalvar 70 mm transparency film. Each matrix contained capital letters of the alphabet and numbers from zero to nine in each of the seven colors produced by the projector. The total of 252 symbols was arranged in an 18 by 14 format, with alphanumerics located at random throughout the matrix.

Relevant Display Variables

To the left of the projector, 15 degrees offset from the 20-foot screen-projector axis, the subject's chair was fixed to the floor so that his eyes were approximately 18.5 feet from the screen center. The letter height on the screen was approximately 1.75 inches, and the display characters subtended a visual angle of 27 minutes, well above the generally accepted lower limit for visual color displays.[6]

Ambient light was introduced by fluorescent desk lamp placed at the rear of the display area, facing the screen. The fluorescent ambient, chosen as being one common to work areas, was reflected from the screen in the order of 0.09 foot lamberts. Display color brightness, measured within the stroke-width of particular characters, ranged from 0.12 ft-L for the dimmest blue character to 0.70 ft-L for the brightest white character. These figures include the ambient brightness on the screen.

While perfect registration of one primary-colored character with another on the screen to produce a multi-primary mixture, *i.e.*, yellow, magenta, cyan and white, was desirable, this quality of registration was not generally attainable in the rapid change required from one stimulus slide to another. The maximum allowable misregistration on the screen for the present experiment was set at 33 percent of stroke width or approximately one quarter inch of primaries appearing beside the color mixture stroke. The slide and projector optics were adjusted until this criterion was met or surpassed. While some misregistration was unavoidable, up to 33 percent, where possible it was confined to magenta characters, since a previous study on the effects of misregistration[8] demonstrated that misregistration was tolerable beyond 33 percent and that the magenta code was least affected of the color mixtures.

Subjects were six male college students with visual acuity of 20/20 corrected or uncorrected. The subjects had normal color vision as tested by the Bausch and

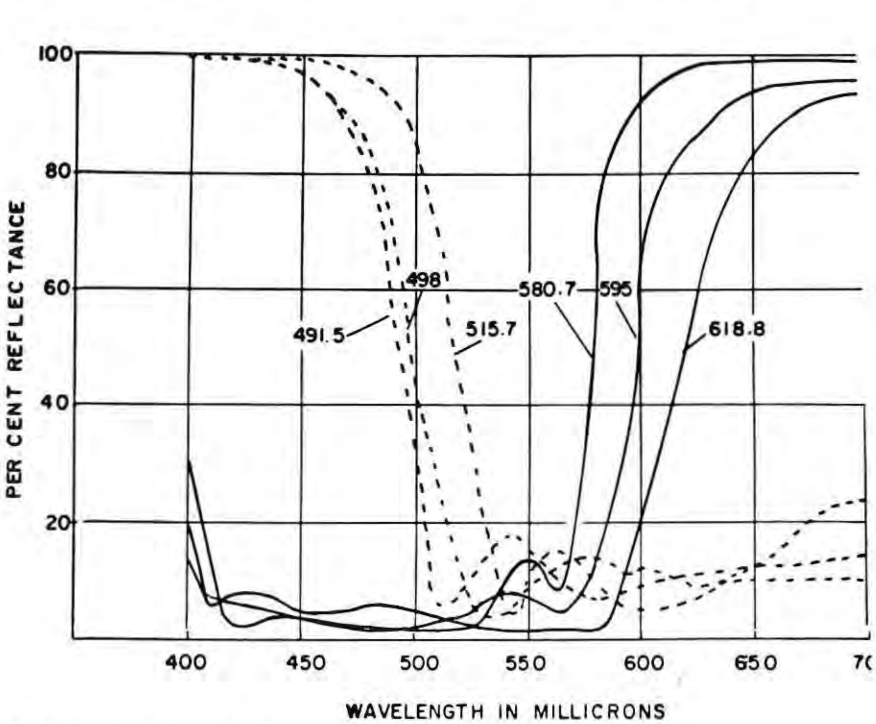

FIGURE 2: Spectral reflectance of dichroic filters at 60° angle of incidence.

Lomb Orthorator color plate.

Experimental Design

A 2 x 9 x 7 factorial design with partially repeated measures was used. There were two orders of presentation of filter pairs. Three subjects viewed pairs 516-595, 498-595, 491-595, 491-619, 498-619, 516-619, 516-581, 498-581 and 491-581, and red reflectors respectively. The other three subjects saw filter pairs in the reverse order. This counterbalanced design was a method of controlling any learning effect during the experiment, such as subjects' memorization of matrices. All subjects viewed the nine possible combinations of the blue and red filters and each of the seven symbol colors for each filter pair.

Subjects were given two preliminary practice sessions of four slides each to familiarize them with the task and stabilize their response. In the experiment each group of three subjects saw one filter pair each day. For each pair, Ss saw all six alphanumeric randomizations twice. The twelve scores were averaged for each symbol color at each filter pair to provide a combined score of alphanumeric randomizations and two exposures.

For each trial Ss were instructed to read as many alphanumerics of the experimenter-designated color as possible within the 15-second exposure time. Performance was recorded in terms of the number of correct responses, that is, the number of characters of the E-designated color that S read in the proper order. Correct responses per exposure were determined to be the measure having the greatest overall sensitivity and was also directly obtainable from the S's response, without requiring subjective judgment regarding the types of errors made.

Results and Discussion

Appropriate statistical tests were performed on the data and may be found in the RADC Technical Report which summarizes procedures and data handling techniques.[9] For the sake of brevity and clarity, graphical presentation was selected for this report.

Effect of Filter Pairs

Statistically significant differences were found among filter pairs. As shown in Figure 3, subject performance was highest for dichroic filter pairs 516-581 and 516-595. The cross-hatched filter pair, 498-595, was supplied by the projector manufacturer and produced observer performance not statistically different from any filter pairs but 516-581 and 516-595. The least efficient dichroic filter pair appeared to be 491-619, which produced the least amount of energy in the blue and red channels and which "loaded" wavelengths in the green. However, statistical tests for differences could not discriminate between the 491-619 and 498-595 pairs.

One noteworthy aspect regarding the differences between performance on different filter pairs was their relatively small magnitude, as shown by the few statistical differences actually obtained.

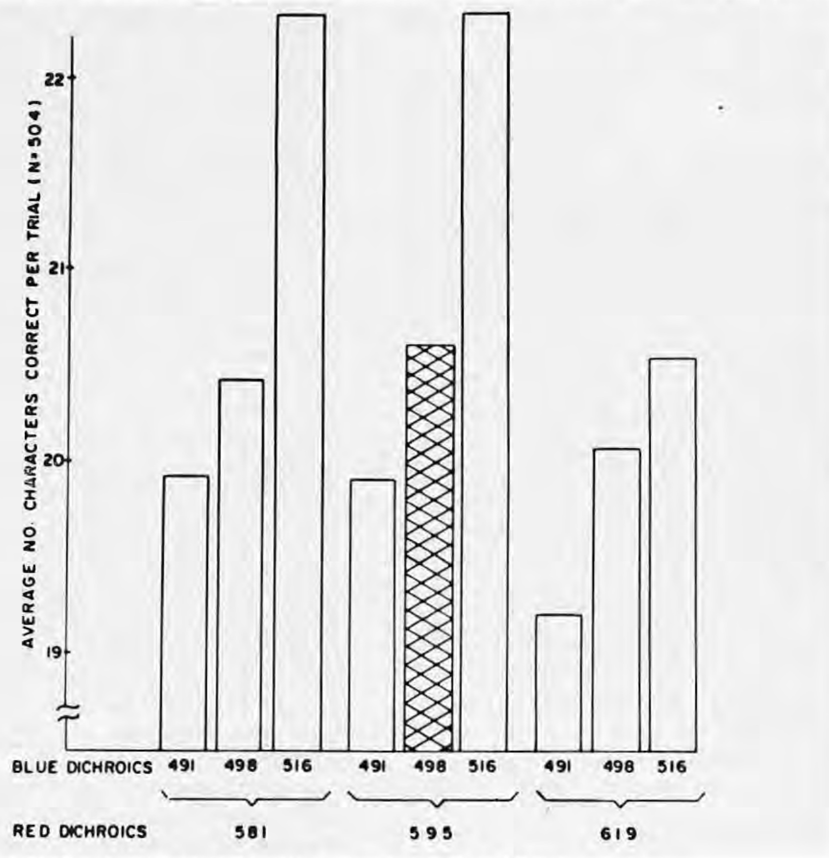

FIGURE 3: Subject performance for filter pairs averaged over all conditions.

It can be seen that some level of proficiency was maintained with even the most extreme values of filters, 491-619. This result tends to generalize to display applications the ability of the human observer to perceive many physically distinct stimuli as parts of a single category of stimuli, the phenomenon of color constancy. The old problem of the "limitations" of the human observer in discriminating a number of colors is in reality a two-headed coin.

It is not unknown in display circles to hear some naive person wishing aloud for the capability to code in 30 or 40 colors. If, indeed, the average individual could readily discriminate this number and, even more practically, if enough data categories could be found to fill these codes, imagine the potential for sheer confusion in the combat control room. The slight color shift of an aging light source, a bit of nicotine on a filter, some mayonnaise from an errant technician's sandwich smeared accidentally on a projection lens, could all result in an observer placing, with the greatest certainty, information in the wrong pigeonhole.

The most efficient of the three blue filters used was the 516 filter, which reflected the greatest amount of light energy into the blue projector channel. A direct relationship between relative energy in the blue channel and overall performance is apparent in Figure 3. Two red filters, 581 and 595, produced consistently higher performance than the third, 619, which reflected energies closest to the infrared, produced a low-brightness red symbol, generally appeared to degrade the color mixtures of which it was a part, and tended to desaturate the green color code, a residue of the other two primaries.

Effect of Symbol Colors

Significant differences were also found among symbol colors, with subject performance, shown in Figure 4, highest for the red, lowest for the green. Tests of specific differences grouped symbol colors into three general groups, red and yellow superior, magenta and white intermediate in effectiveness, and cyan, blue and green rendering the lowest performance.

Parallels may be drawn between these and findings in a previous study[8] in which identical apparatus and similar tasks were used. In the latter effort, dealing with the variable of misregistration, at perfect registration, using filters 498 blue and 595 red, the order of symbol color efficiency was red, yellow, blue, magenta, white, green and cyan. The only major discrepancy in the two findings was the relative position of the blue symbol color. However, in the misregistration experiment, investigators employed very high display brightness and negligible ambient illumination to maxi-

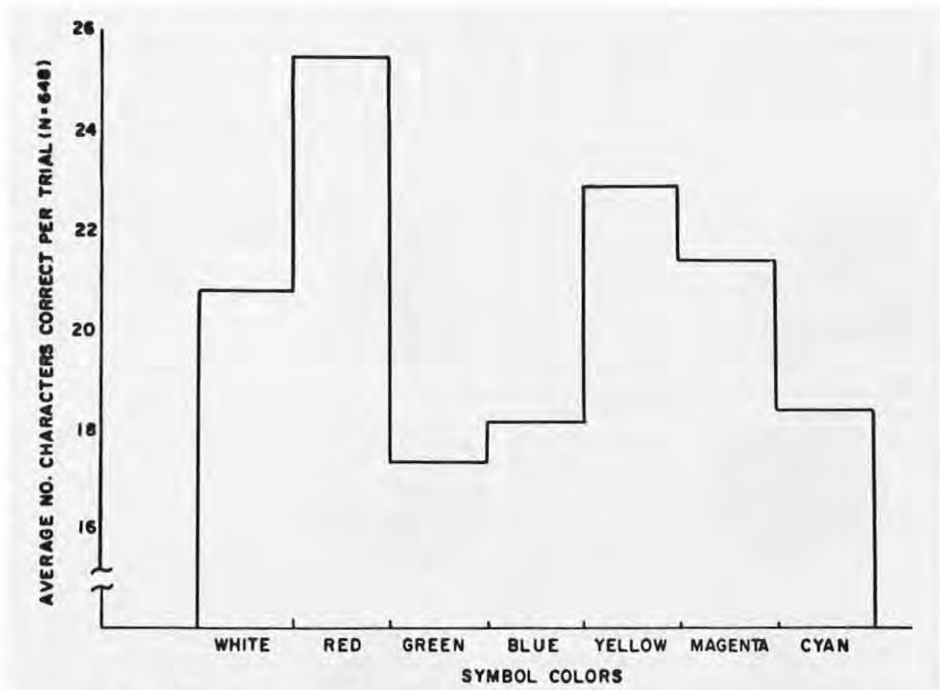

FIGURE 4: Subject performance for symbol colors averaged over all conditions.

mize misregistration visibilty. In this task measures were taken to compensate for these factors more probable levels in the field. Consequently, it appeared one of the detectable effects of reducing the overall contrast ratio between symbol and background was that the blue symbol color was extraordinarily degraded.

Another important feature in the data on symbol color is the relatively poor performance turned in on the green symbol color. The peak of the luminosity curve for the human eye in the green area of the spectrum is a well-known characteristic. As a result, it is generally assumed that green is an excellent coding color. In this and the misregistration[8] studies, the reverse has been found.

One explanation for the difficulty with green is the fact that in the present investigation the three primaries were separated by interposing in the light path first a blue, then a red filter, with the remainder being directed into the green. In the majority of filter combinations, the green symbol color was very desaturated, too bright and quite similar in appearance to cyan. Radiometric readings taken with an Eppley thermopile confirmed that in only one case, 516-581, was the intensity of the green channel approximately equal to that of either of the other two, in terms of physical units. In terms of psychological brightness, green was always higher. The obvious conclusion is that the advantage of green has not been utilized.

One of several alternate measures of performance was the frequency of color confusion or inclusion of other-colored symbols in the reading of E-designated symbols. The particular confusions and the colors most often confused were tabulated and appear in Table I.

TABLE I: Symbol color confusion matrix.

Symbol color Inserted	Symbol Color Being Read	Percent of Responses Insertion Occurred
GREEN	CYAN	5.3
WHITE	YELLOW	3.7
CYAN	GREEN	2.7
YELLOW	WHITE	2.5
MAGENTA	RED	1.6
RED	MAGENTA	1.1
CYAN	BLUE	.0004

According to this criterion, green was the least acceptable color code, since 5.3 percent of the responses made to cyan were actually directed at green symbols that appeared to be cyan. White symbols were read as yellow more often than the converse.

The blue symbol color was never observed as being read for another color, but in five instances cyan symbols were read as blue symbols. The green-cyan, white-yellow confusions are particular aspects of symbol color effectiveness and not readily apparent in the overall correct-items-per-trial score.

Conclusions

For the present optical arrangement, an order of blue reflector/red reflector and a xenon source, a blue dichroic filter having a 50-percent cutoff of approximately 516 mμ or possibly higher and a red dichroic filter with a 50-percent cutoff of between 581 and 595 mμ are recommended. Data do not support an insistence on narrow tolerances in filter specification.

An alternate arrangement of dichroic filters may prove more satisfactory and will be investigated, namely using a red reflector first, with cutoff of between 580 and 595 mμ, followed by a yellow reflector cutting off at perhaps 520 or 530 mμ, with the third channel being a high-brightness blue. By removing some of the brightness from the green and shifting it into the blue, the following advantages would be gained:

1. Green and cyan would differ more greatly in brightness as well as hue and would probably be more discriminable.
2. Blue would appear brighter, hence more legible symbology would result without detracting from the apparent advantages of blue, namely hue uniqueness and attention-getting ability (suggested by Table I).
3. Conceivably, the confusion between yellow and white would be obviated to a greater extent, since yellow would appear less bright and more saturated than in the present study.

Acknowledgement

The author is indebted to the Display and Information Systems Division, International Electric Corporation, Paramus, N.J., for the production of stimulus material and for advice on projector operation and to Dr. Raymond J. Christman who supplied invaluable criticism.

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Circle Reader Service Card No. 23

on the move

John L. Coddington has been named general manager, Magnetic Shield Div., Perfection Mica Co., at Chicago, filling a vacancy left by the death of **Glenn Powers.** Coddington was formerly AF marketing requirements mgr. for Texas Instruments' Apparatus Div. in Dallas.

John A. Postley has been named VP/ Advanced Information Systems of Informatics Inc., according to pres. **Dr. Walter F. Bauer.**

Robert V. Head has joined Computer Sciences Corp. as mgr. of Management Information Technology.

Amperex Electronic Corp. has promoted **Al Katz,** former product mgr. for Communication Tubes, to the newly-created post of mkt. mgr., R. F. Products; and **Allen Merken,** former product mgr. of Digital Products Group, to mkt. mgr., Components Division.

Elwood E. (Pete) Bolles has been named dir. of engrg. at Bunker-Ramo Corp.'s Defense Systems Div., replacing **Arthur P. Stern,** who has resigned.

California Computer Products Inc., has named three executives as VP's — **Howard E. Brewer,** chief eng., **Keith Kelsay,** dir. of mfg., and **Richard L. Mark,** dir. of comm'l mktg. **Jerrold Asher** has also joined the firm as mgr. of mktg. research.

John Messerschmitt, VP of Amperex Electronic Corp., Hicksville, L.I., N.Y., announces the promotion of **Arnold I. Spain** to the position of Product Manager in the Electronic Components Department.

Herner and Company, Washington, D.C., has announced the appointment of **Melvin Weinstock** as a Senior Resident Consultant. Prior to joining Herner, Weinstock was Senior Agricultural Advisor in Farm Corporations to Agway Inc., Vineland, N.J.

The appointment of **Joseph F. McCarroll Jr.** as Director of Systems for the Bunker-Ramo Corp., Stamford, Conn., was announced by Marketing Director **Anthony A. Barnett.**

Patrick Byrne has joined California Computer Products Inc., Oakland, Calif., as product specialist, a newly-created post. **Richard L. Mark,** marketing director of commercial products, said Byrne will concentrate on marketing the firm's automatic curve follower systems in Northern Nevada, Northern California, Washington, Oregon, Idaho and Montana.

William J. Burros has been appointed Controller for Dialight Corp., according to announcement by **Ellis Greene,** pres. parent firm's Silver Spring, Md., facility.

Robert A. Larsen has been appointed eastern regional sales mgr. for Fairchild Space and Defense Systems' commercial television systems, Syosset, L.I., N.Y.

Burroughs Corp., Plainfield, N.J., has appointed **Douglas E. Schwartz** to the position of Manager of Advertising and Sales Promotion, Electronic Components. Division, it was announced by Marketing Manager, **Arthur B. Shesser.**

Schwartz Fisher

Charles R. Fisher has been appointed Manager of Engineering, and **Howard I. Jacobs** has been appointed director of marketing for the Data Products Division of Stromberg-Carlson, San Diego, Calif., according to **Carl V. Shannon,** General Manager of the division.

D. Clark Murphy has been appointed Prod. Mgr., data recognition equipment, Communications and Electronics Div., Philco Corp.

K. M. Harden, pres. and chmn. of Traid Corp., Glendale, Calif., has been conferred an honorary Doctor of Laws degree by Seattle University.

ID Products

Step Servo Motors

IMC Magnetics Corp., Westbury, N. Y., has announced three new step-servo motors, the Tormax Size 20 VR, Size 8 VR, and Size 8 PM. Size 20 VR Mark II model 020-010 serves as a sturdy digital control actuator for X-Y plotters, heavy valve positioning, machine tool table positioning, and similar systems. It delivers 12 oz-in of running torque, 45 oz-in stall torque, with response rates to 425 pps, bidirectional, in accurate 15-degree increments.

Size 8 VR is a four-phase variable reluctance step-servo which maintains accurate pulse integrity, responding bidirectionally at rates up to 1162 pps, in 15-degree increments. Weight is 1.6 oz, length 1.075 in; it operates on 8 w input. Size 8 PM is 1.095 in long, weighs 50 gms, is a permanent magnet step-servo motor (Model 008-845) offering precision bidirectional power consumption (1.74 w).

Circle Reader Service Card No. 26

Electron Gun Supply

Litton Industries' Electron Tube Div., San Carlos, Calif., has announced a new model electron gun supply and isolated video amplifier. Designated the Model 1059, the unit is designed for operation of cathode ray tubes operating with grounded anode or depressed cathode, fiber optic cathode ray tubes and demountable electron guns. It provides all gun voltages for electro-magnetically focused CRT's with high voltage isolation to 30 kv standard and 40 kv on special order.

The unit eliminates destruction of the CRT caused by discharge of high voltage isolation coupling capacitors through the tube. Video signals are fed to the CRT by an isolation system possessing a 10 mc video bandpass. The maximum output of the amplifier is 150 volts peak and can be attained at an input drive level of 1 v, with pulse lengths as short as 1 μsec.

Circle Reader Service Card No. 27

Illuminated Push Switches

Jay-El is currently introducing a line of pushbutton illuminated switches for spacecraft applications. These are hermetically sealed, illuminated items designed specifically to meet specs of such programs as Apollo, LEM, and others, on which they are presently in use.

Among those included in the space applications line are the following items for the Apollo program: 2PDT hermetically sealed packages in momentary actions (including lamp diodes in packages); 4PDT electroluminescent units now being qualified for Apollo Block II; 2PDT momentary electroluminescent space switch for LEM computer (package size 0.92 in^2 by 1.6 in. long); and 4PDT alternate action space switch for LEM control panel (in design). Typical applications parameters for the firm's spacecraft lines are: contact 28 v dc, 7 amps resistive, 4 amps inductive; endurance min. 40,000 cycles at 6 cpm 0° to 150°F; range −67° to 248°F; 100% humidity (including water condensation); shock 78 g min.

Circle Reader Service Card No. 28

High-Resolution CRT

Du Mont Electron Tubes Div. of Fairchild Camera and Instrument Corp., Clifton, N.J., announces the development of a high-resolution CRT suitable for various digital and analog applications, ranging from cartesian representations to precision radar displays. The KC2515 provides displays with small spot size, achieved by use of electrostatic focus, magnetic deflection, electronic gun, and fine-grain phosphor.

A 26° deflection angle minimizes deflection defocusing and provides high corner resolution; a phosphor-screen option permits selection of medium-short, short and very short persistence phosphors; an aluminized screen backing increases light output and prevents build-up of spurious-charge effects; and an optional fiber-optic faceplate facilitates transmision of spectral energy generated by the phosphor screen for direct photographic recording of single traces. The KC2515 has a flat-viewing surface, 5¼ in. in diam. and 18¾ in. in length. The faceplate has a minimum viewing area of 4½ in.

Circle Reader Service Card No. 29

"Watering-Can" Projection CRT

Raytheon Co., Components Div., Lexington, Mass., announces the development of a "watering-can" shaped projection CRT said to have longer operating life and increased light output, as compared to standard cathode ray projection tubes. Raytheon's novel design incorporates liquid cooling of the phosphor. Images are projected through a 5 in. optical window. The electron gun is set at an angle and resembles a watering-can spout. The deflection system compensates for trapezoidal pattern distortion.

Light brightness available is 36,000 foot-Lamberts. After projection on a 3 by 4 ft. high directivity screen, screen brightness is 50 foot-Lamberts. Rated operating life of the tube is 500 hours. The tube is expected to find application in business management displays, stock quotation boards, and closed circuit theater television.

Circle Reader Service Card No. 30

6-Digit/Output Encoder

Theta Instrument Corp., Saddle Brook, N.J., announces the availability of a 6-digit encoding system, an addition to the firm's line of 4-digit devices. The encoder features an absolute, parallel decimal output to drive readouts and printers without the need for code converters. As an option, BCD code for precise computer interfacing is simultaneously available.

Unlike most encoders, the Theta device produces a high power, on-the-fly output. Electrical levels to 115 v, 5 amps dc are available. Primarily employed to digitize such parameters as linear position, angle, weight, and pressure for display purposes, the encoder circuitry also produces outputs which are easily used for alarming, sequencing, and motor control.

Circle Reader Service Card No. 31

Multiplex Fiber Optics

Poly-Optic Systems Inc., Paramount, Calif., has announced a new type AST polymer fiber light bundle that offers many advantages over the glass type, according to the manufacturer. Termed Multiplex® bundles, they provide improved flexibility and are almost indestructible. The bundles reportedly provide transmission characteristics superior to glass, especially in the ir and violet regions of the spectrum. Light loss from bubbles and chipped cladding is eliminated. Non-breakable characteristics allow the use of a thin, lightweight sheath rather than the bulky stainless steel convoluted tube usually required with glass. Two types of light sources are available.

Circle Reader Service Card No. 32

Hanging Device

Hangit, a new hanging device with a multitude of uses, now is available from the Evans Specialty Company Inc., Richmond, Va. A patented 12-in. aluminum hanging strip, Hangit hangs papers of all types quickly, easily and neatly. Two or more units, spaced apart, can be utilized for papers wider than 12 inches.

Rollers inside the hanging strip firmly grasp paper to be hung; paper is released instantly by pulling up and away. The unit eliminates thumb tacks, tapes, space-consuming bulletin boards. Using pressure sensitive tape for accurate, permanent positioning, Hangit can be mounted on any surface, and installed in seconds. A screw mounting is also available. Evans handles a wide range of office and school supplies including Tacky-Finger, finger tip moistener; the Punctuator; U-Bow desk and collating racks; and Sorba-Sound machine cushions.

Circle Reader Service Card No. 33

Photomultiplier Power Supply

A universal regulated power supply for operation of photomultiplier tubes at up to 1800 v dc has been introduced by Vector Engineering Inc., Springfield, N. J. The stock unit, Model PM-1K-01A, provides continuously variable output of 200 to 1800 v dc in two ranges at 0-10 ma. Static regu-

Circle Reader Service Card No. 34

lation is ± 0.001% for a 10% line change at constant load. Load regulation is 0.001% from no-load to full load at constant line input. Ripple is a 2 millivolts peak-to-peak. Stability is 0.01% per hour.

Output voltage and current are continuously monitored by a pair of 2% accuracy front panel meters. Coarse and fine voltage adjust controls provide accurate output voltage settability. Ambient temperature operation is from 0 to 50°C. Units are available in 3½ in. high standard relay racks or bench models.

Circle Reader Service Card No. 36

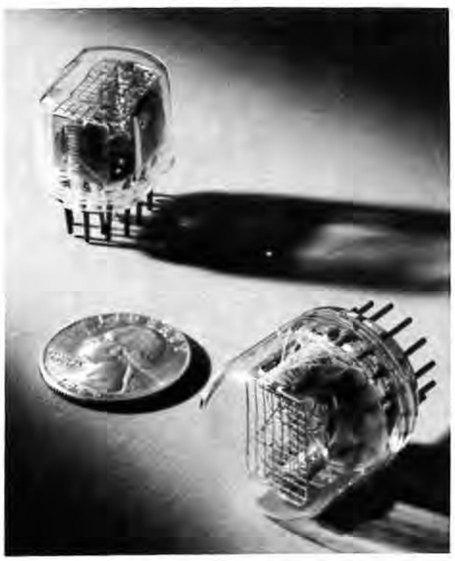
Implosion-Protected TV Tubes

Westinghouse Corp.'s Electronic Tube Division, Elmira, N.Y., announces the availability of a 21-in., 114-degree black-and-white television picture tube having an integral implosion protection system and integral mounting bracket. This tube, reportedly the first commercial model of its kind, utilizes a prestressed banded implosion system comprised essentially of a metal rimband and a steel tension strap. The rimband, curved to fit snugly around the periphery of the tube face, is epoxy-bonded to the glass. A steel tension strap is then prestressed tightly over the rim-band and mechanically clinched in place to maintain a residual tension in the system.

A special tinted glass in the tube's viewing area improves picture contrast, and four integral mounting brackets ("ears") facilitate mounting in the cabinet, the manufacturer states. The construction of the tube and its implosion protection system is adaptable to many picture tube types which differ only in electrical characteristics.

Circle Reader Service Card No. 37

End-Viewing Indicator Tubes



Two end-viewing numerical indicator tubes have been introduced by Raytheon Company's Components Division, Lexington, Mass. The new Datavue tubes have conventionally-shaped numerals from 0 through 9. Each brightly illuminated numeral is ⅝ in. high and can be read easily from distances up to 30 ft. even in a fully lighted room.

The CK8421 is a round tube, and the CK8322 has a rectangular cross section. Each measures approximately 1 in. height and 1 in. diameter (or maximum cross sec-

Circle Reader Service Card No. 45

tion). The tubes meet all EIA electrical and mechanical specifications for end viewing numerical indicator tubes of this type, and can be freely substituted in existing sockets, according to the manufacturer. A complete line of Datavue indicator tubes, both end view and side view, Datastrobe digital readout subsystems, character generators, and other alphanumeric components and subsystems is described in literature offered by the company. Complete specifications are available from Raytheon.

Circle Reader Service Card No. 41

Display System

A unit which simultaneously displays changing information from up to 128 data channels in bar-graph form on a compact 17-inch CRT has been announced by the Telemetrics Div., Technical Measurement Corp., Santa Ana, Calif. Although up to 128 data channels can be accurately measured or compared, the 650 Display System can hold data on as many as 256 channels in an internal core memory. Individual switches permit any channel display to be intensified as desired.

Data channels which would normally require 128 separate meters are displayed on a single oscilloscope with relative magnitude of each channel instantly visible, providing a practical, high-accuracy, quick-look at system performance. Data displayed may be decommutated telemetry data, computer outputs, multi-channel industrial instrumentation, the digital output from a spectrum analyzer, medical instrumentation, or any source of continuously updated data. Calibration circuits automatically generate calibration markers at intervals of 25% of full-scale. A front panel switch permits checking the calibration values stored in memory against an internal standard.

Circle Reader Service Card No. 42

Rear-Projection Readouts

Modified versions of the SRO-100 rear-projection 12-message readout featuring a reported increase in readout character size of 100% over standard units, and a 50% increase in image brightness and contrast, are now in full production at Shelly Associates (Formerly Cal-Glo Company), El Segundo, Calif.

Each of the 12 precision optical systems in the miniaturized units can now project characters, symbols, or six-line messages to a height of 0.700 in., to occupy a maximum area on the 1 in. viewing screen. Further modifications have resulted in a 50% increase in the brightness of images projected on the viewing screen, and an exact focus that eliminates stray light to increase overall contrast for optimum readability under typical ambient light conditions, according to the manufacturer. Modified SRO-100 units also include an optional lamp assembly for based miniature lamps to offer the choice of based or un-based lamp configurations. Either lamp type is easily field-replaceable without tools of any kind.

Circle Reader Service Card No. 47

Fiber Optics CRT

Electronic Tube Div. of General Atronics, Philadelphia, Pa., recently introduced a high-resolution 1-in. useful screen diameter CRT, available with or without fiber optics faceplate. The fiber optics version offers a full-screen fiber area for direct contact record-

ing of displayed phenomena. Packaging flexibility is offered through a choice of separate or integral bases.

The tube, Model M1236, features high output and 1000 lines/in. resolution. It is Mu-metal shielded against external magnetic fields. High electrostatic deflection sensitivity is provided for transistorized applications. The unit is a micro-display monitor ideally suited for extremely fine detailed observation of military and industrial phenomena.

Circle Reader Service Card No. 52

Signal Line Isolator

The Bunker-Ramo Corp., Canoga Park, Calif., has developed an all solid-state signal line isolator with isolation characteristics never before attained in commercial units, the firm claims. The device couples timing, control, or data signals between input and output circuits without a conductive path between them or any measurable coupling through electronic magnetic fields. Extraneous signal attenuation is over 100 db in both the forward and the reverse directions from dc through 25 gc. Digital signals may be transmitted at rates from dc up to 100 kc; higher frequency response can be optionally provided.

The signal line isolator consists of an optical coupling system employing an emitter and sensor that are separated by a conductively — and electromagnetically — shielded interface. Input and output circuits are provided to match system input and output characteristics. A flange near the center of the isolator, and an RF gasket, are provided for mounting through a shielded compartment wall to preserve the high isolation feature. The signal line isolator meets or exceeds all government specifications for this type of product. It measures 0.80 in. by 0.85 in. cross section by 4.25 in. long, has a 1.80 in. square mounting flange and weighs 9 oz.

Circle Reader Service Card No. 53

Desk-Top Electronic Calculator

A solid-state electronic desk-top calculator, believed to be the world's smallest and fastest, has been introduced by Wang Laboratories Inc., Tewksbury, Mass. Able to perform all normal arithmetic computations in a fraction of a second, the Model 300 has a keyboard/display console scarcely larger than a telephone. According to Wang, the calculator not only provides fast internal data manipulation, but permits considerably more rapid keying, requiring depression of only 0.002 in. to enter a number or perform an operation.

The unit is noiseless, and answers are displayed instantaneously on the console in clear, lighted chracters ⅜ in. high against a dark background. The automatic floating decimal point instantly finds its correct place every time, without presetting. Many complex operations, such as duplex product and entry accumulation, are performed easily and quickly. Two independent, (but interconnected) addition/subtraction sections are available and serve as storage registers for the accumulation of sums and products. A third section handles multiplication and division. Entry and recall from any of the registers is performed by a single keystroke. Two models are available.

Circle Reader Service Card No. 54

Flashing Indicator Lights

Dialight Corp., Brooklyn, N.Y., announces the addition of its first flashing light to its extensive listing of indicator devices. Utilizing a unique characteristic of high brightness neon lamps in combination with solid state components, flashing operation is obtained on 110-125 v ac power without moving elements or contacts. The light mounts in a ½-in.-clearance hole.

Miniaturized driving circuitry on a tiny card is enclosed within the slender body of the light; an extending edge of the card exposes eyeletted openings for external wire connections. Based on life tests at maximum voltage, the NE-2J lamps utilized have an average life of 500 hours. Lamp replacement is made from the front of the panel.

Circle Reader Service Card No. 55

Book Review

FIBER OPTICS, A SPECIAL REPORT, Bagley et al, Management Reports, 38 Cummington St., Boston, Mass., 1964; 92 pages, illus. $17.50 postpaid. Fiber-optics Technology, while not completely understood, is widely recognized for it's potential usage in industry. This report which delves into the commercial aspects of Fiber-optics, is the result of an exhaustive study by a team of nine graduate students of the Harvard Business School. The report is written in three major sections. Section one includes chapters on fundamental theory of fiber-optics. Also, included in section one, is the technology related to the manufacturing process. The theory included in section one is presented in a concise manner directed towards a semi-technical audience. The scope of the material presented in section one includes a rather complete discussion on light transmission theory, resolution, bend radius, configuration of fiber bundles and wave-guide theory.

For the manufacturing process the manufacturer will find the needed technique to manufacture fiber bundles. The machinery is found to be very inexpensive and simple, while the personnel needed to run the machinery and produce a high quality product at reasonable cost is the most difficult task. The making of fibers is still largely an art, and mass production technique is still not in sight. Finally the authors feel that temperature control is considered the most critical factor in the manufacturing process.

APPLICATION SECTION: Fiber optics are adaptable to a wide variety of applications. While the detailed information concerning every application is hard to obtain, the authors managed to present a list of present and future applications.

Optical Applications such as information processing, optical wiring and pattern recognition are possible, due to the very good pattern resolution ability and the optical response time, with present day fiber optics. In the audio application a very interesting device called the sceptron is introduced. This device uses optical fibers for audio frequency information processing and pattern recognition.

Electronic Applications such as optical computer logic, a contactless potentiometer, high speed printer and an image intensifier, are discussed briefly in the text.

Control and Inspection Applications are also discussed by the authors. This application includes inspection of the interior of a rocket fuel tank, core inspection of a nuclear reactor, and aircraft fire detection.

Medical Applications are finding wide acceptance due to the unique characteristics of flexibility and remote accessibility properties of the fiber optics. The gastroscope, esophagascope and ureterascope are some of the medical applications discussed.

The final section of the report includes marketing information and recommendations for the future development of the fiber optic industry. The authors consider the present fiber optic industry to be very uncoordinated, and to be dominated by overly conservative manufacturers. Therefore, the authors recommend that a trade association be formed. This will open new lines of communications, thus insuring a freer exchange of information. A trade association would also establish a joint marketing effort and provide for more directed research.

In conclusion, while several important topics are discussed in this report, its value lies in the bibliography at the back of each section.

Rex Huo
Giannini Controls Corp.
Duarte, Calif.

MINIATURE PACKAGED SCAN CONVERTERS

. . . New Products for Avionics . . .

SUBMINIATURE SCAN CONVERTER MODULE
INCORPORATING RW-13 TUBE

PACKAGED MINIATURE AND SUBMINIATURE SCAN CONVERTER TUBES FOR MULTI-SENSOR DATA STORAGE AND PROCESSING

The Warnecke RW-5EM and RW-13 are specially designed to meet the growing demands for packaged miniature and subminiature scan converter tubes. In their complimentary package of shield, coils and leads, the tubes meet the requirements for the MIL-E-5400 military airborne environment.

Small size has been achieved without sacrificing resolution. The RW-5EM resolves 1200 TV lines and the RW-13 resolves 840 TV lines, at 50% relative output amplitude for orthogonal writing and reading.

The storage surface is of the EBIC type, and information can be stored indefinitely until readout. Readout time can be custom tailored from a single scan to several thousand depending upon the application.

The tubes feature a capability for quick erase of all stored information, or erasure of selected information.

Magnetic focus guns have been designed to eliminate the need for dynamic focus.

TYPICAL PACKAGED SIZE AND WEIGHT

RW-5EM	13⅜″ long x 3″ dia.	6 lbs.
RW-13	10″ long x 2″ dia.	2¾ lbs.

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ID Readout

FJCC Technical Program

The technical program for the 1966 Fall Joint Computer Conference is taking shape. Assessments of papers arriving by the close of submissions in May indicated up to 24 sessions will be planned for the technical program, Nov. 8-10 at San Francisco's Civic Center. Dr. William H. Davidow, chairman of the technical program, has announced the following sessions, with chairmen shown, as firm:

"Time-Sharing Processors and Executive Systems," Dr. Gene M. Amdahl of IBM Corp., San Jose; "Integrated Electronics and the Future of Computers," Prof. James B. Angell of Stanford University; "Computer-Oriented Data Analysis," Dr. Geoffrey H. Ball of Stanford Research Institute; "Some Communications Aspects of Time-Sharing Systems," Paul Baran of The Rand Corp.; "Hybrid Applications and Techniques," Walter Brunner of Electronics Associates, Inc., Princeton, N. J.; "The Man-Machine Interface," Dr. Sidney Fernbach of Lawrence Radiation Laboratory; "Selected Applications Using Numerical Analysis," R. W. Hamming of Bell Telephone Labs, Murray Hill, N. J.

"For and Against Time-Sharing," Prof. Harry D. Huskey, University of California at Berkeley; "Technologies and Systems for Ultra-High Capacity Storage," J. D. Kuehler of IBM Corp., San Jose; "Advances in Programming Languages," William C. McGee of IBM Corp., Palo Alto; "Engineering Design by Man/Computer Interaction," Thurber J. Moffett of Lockheed-California Co., Burbank, Calif.; "Computers and Publishing," William R. Nugent of Inforonics Corp., Maynard, Mass.; "Computer Memories," Dr. J. A. Rajchman of RCA Laboratories, Princeton, N. J.; "Monte Carlo Methods Using Analog and Hybrid Computers," Prof. A. C. Soudack of the University of California at Berkeley; "Error Analysis in Analog and Hybrid Computers," Dr. Robert Vichnevetsky of Electronic Associates, Inc., Princeton, N. J.; and "Computers in Music," Dr. Heinz Von Foerster of the University of Illinois.

A workshop session is planned on "The Complements of Man/Computer Interaction," with Thurber J. Moffett as chairman. Also proposed are the following sessions, according to Dr. Davidow; "Natural Language," H. R. J. Grosch of General Electric Co., Santa Barbara, Calif., "Scientific Applications," L. H. Amaya of Lockheed Missiles & Space Co., Sunnyvale, Calif.; "Management of Time-Sharing Centers," Prof. Richard Mills of Massachusetts Institute of Technology; "Impact of Computers on Government," Norman Ream of the Center of Services and Technology, U. S. Bureau of Standards; and "High Quality Papers of General Interest," Rex Rice of Fairchild Research Lab, Palo Alto.

Apollo Computer Program Contract

Philco WDL Division, Philco Houston Operations, has been given a $1.6 million contract to implement, program and operate a computer system in conjunction with Apollo space flight simulations. Called the Apollo Process Control Unit, it operates in conjunction with MSC's GS Simulation Computer (an IBM 360/75) used for the Apollo Simulation, Checkout and Training System (ASCATS), also under and -fabricated equipment will tie the Process Control Unit into ASCATS. Equipment includes a multi-channel telemetry multiplexer/distributor and interface equipment to connect the computer to six ASCATS control and display consoles from which Apollo simulations are run.

Congress on Information System Science/Technology

The Third Congress on Information System Science and Technology, jointly sponsored by The Mitre Corp. and the AF Electronic Systems Division, convenes Nov. 21-22 at Buck Hill Falls, Pa. Attendance is by invitation, limited to 350 members.

June SID Board Meeting: Summary

[The following is the first of an innovation in *Information Display*, in the constant effort to provide more complete information on activities of the *Society for Information Display*. Additional summaries of board notes will be published as quickly as possible after they become available. — Ed.]

The *SID* Board of Directors met in Washington, D. C. on June 15, 1966. A contract to produce the official *SID* lapel pin was award to Balfour. The pins will be available at the 7th National Symposium of *SID* in Boston, October 18 through 20. A National Repository Sub-committee has been established, chaired by Frederick E. Smith, of Litton Industries, Data Systems Division. The sub-committee is part of the Publications Committee. Mr. Marty Waldman, Editor and Publisher, *Information Display*, was named as Chairman, Publicity Committee. Means for more effectively handling membership records were discussed and Sol Sherr, in conjunction with the Regional Directors, was asked to look into suitable systems. Phil Damon presented a new memberbership form which was approved. Executive Secretary, Dr. Luxenberg, was requested to gather data on location and costs of office space that could become the full-time Society headquarters. A decision as to whether or not to establish such a headquarters will be made at the next Board meeting ing Boston this fall. Status reports were also made by the Treasurer, Standards and Definitions Committee, and the Publications Committee. The next Board meeting will be held on October 17, 1966, at the 7th National Symposium, Boston. — Carl Machover, Secretary, *SID*.

Improved Chapter Communications Planned

As a means of improving the written communication between our members themselves and the Industry at large, the various Chapters of the *Society for Information Display* have appointed Publicity Chairmen. These appointees are:

Mid-Atlantic Chapter ....Gordon Burroughs
Los Angeles Chapter ....Louis M. Seeberger
Boston Chapter ....Harry Poole
San Diego Chapter ....Hugh Larsen

Appointments from the San Francisco and Washington Chapters are pending and hopefully will be available for announcement in this space in the next issue.

The Publicity Chairman for each local activity will provide newsworthy material on Chapter affairs and people for publication in the *Information Display* Journal. Additionally they will act as "forward scouts" for technical writings of possible interest for *Information Display* articles.

Los Angeles Chapter: The June meeting of the Los Angeles Chapter was held at the Saddle Back Inn in Santa Ana, California. Dinner was followed by a visit to the Opcalite Company where the members were treated to a demonstration of a linear radiometer and a trichromatic integrating computer. This combination of equipment is used by Opcalite to obtain precise and rapid measurements of the spectrum of the radiated energy from light sources such as those commonly used in illuminated displays. This equipment has been of particular value in the design and evaluation of incandescent and electroluminescent instrument panels. Changes due to aging or intentional variations in components and materials may be quickly evaluated for specification purposes.

The above meeting was the last of the current season for the Los Angeles Chapter. The next Chapter affair, to be held in September, will be an installation meeting for the new officers for the '66-'67 year. Mr. Tom Curran, RCA West Coast Division, Van Nuys, Calif., has been appointed Nominations Chairman and is currently assembling a slate of candidates for local election. – L. M. SEEBERGER, Publicity, Los Angeles Chapter.

Business Notes and News

CONTROL DATA CORP., Minneapolis, Minn., demonstrated a variety of products for "total information systems" at the recent Spring Joint Computer Conference of the AMERICAN FEDERATION OF INFORMATION PROCESSING SOCIETIES (AFIPS) in Boston. Demonstrations featured a computerized information system employing the firm's 210 Visual Display System with six CD 211 Entry/Display Stations; four CD 6060 Remote Calculators linked to a computer in Los Angeles; a CD 915 Page Reader; and the CD 6090 Remote Station, linked to a computer in Minneapolis . . . NORTHROP CORP., Palos Verdes Peninsula, Calif., has received a $4.1 million contract in connection with TIPI (Tactical Information Processing Interpretation), a joint U.S. military service program. The TIPI program will develop portable field intelligence processing units to keep pace with modern aerial and reconnaissance equipment, for utilization in tactical command centers . . . CALIFORNIA COMPUTER PRODUCTS INC., Anaheim, Calif., has received a contract in excess of $914,000 from the Army's Frankfurt arsenal for the production of FALT computer logic testers and auxiliary equipment, to be utilized for field testing of the FADAC automatic artillery fire control system . . . Under subcontract to BENDIX COMMERCIAL SERVICES CORP., MILGO ELEC-

TRONIC CORP., Miami, Fla., will supply the entire Target Acquisition and Display System for the NATO tactical Missile Firing Installation to be installed on the Island of Crete, designated Project NAMFI. Under another subcontract, to LE GROUPE SCIENTIFIQUE, of France, Milgo will supply the Data Transmission Link for Project NAMFI. The two contracts are reported to total $500,000 . . . Luminator Div. of LUMINATOR-HARRISON INC., Chicago, has announced sales of $905,000, new business of $1.4 million, and profits of $48,000 for the period ending April 30 this year, as compared to sales of $884,000, new business of $772,000 and net loss for the same period last year . . . RED LAKE LABORATORIES, Santa Clara, Calif., has been appointed to a special dealership covering EASTMAN KODAK photo-instrumentation films in 16-, 35- and 70-mm in normal as well as special emulsions . . . B-R DATA SYSTEMS INC., has been formed in Silver Spring, Md., as a subsidiary of THE BUNKER-RAMO CORP., Canoga Park, Calif., to engage in computer programming and systems analysis, and developing information management systems for government and industry.

Test Telecasts Switch to Analog Computation

Columbia Broadcasting System recently announced it is now utilizing an analog computation system to tabulate studio audience votes in CBS News' National Test broadcasts. The unit was designed by Weston Instruments, and constructed by the CBS Special Effects Dept. The system, in actual use, allows 100 audience participants to press any one of five buttons at their seats to indicate a choice of answers to various questions; the system totals votes in each category and displays results in less than 0.25 sec. Key component is an optical Projected Moving Scale (PMS) meter (Model 1209) designed by Weston; five are employed in the CBS system.


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RESEARCH

ID Authors

A. C. Stocker

Excepting his service with the Navy during World War II, A. C. Stocker has worked with the the Radio Corporation of America since 1928. He has designed a wide range of devices; his experience with Cathode Ray Tubes began in the early 1930s, and extends to date. He has performed a number of systems studies, including studies of display systems, and for the past six years he has been a specialist in display techniques. This background leads him to believe that the best opportunity for advance in the display field is in the application and use of displays. Mr. Stocker received his BEE from Ohio State University in 1928.

Paul Horowitz

Paul Horowitz is currently engaged in Controls and Display analysis and definition for an Air Force contract, as well as directing advanced display system studies with Aerospace Systems-West department of the IBM Federal Systems Division. He received his BA in Applied Psychology from California State College (1958), and has completed graduate studies in Systems Design and Analysis, Display Design, Biotechnology, Optics, and Computer Design. Prior to his association with IBM, he was engaged in highly specialized research projects with Systems Development Corp., Ramo-Wooldridge, Aeronutronic, and North American.

Carl Machover

Carl Machover is Manager of Sales, Information Displays Inc., Mt. Vernon, N.Y., and National Secretary, *Society for Information Display.* During the past 15 years, he has been concerned with design and marketing of display devices, servo components, and related equipment. He holds two patents, and is the author of two books and several articles concerning displays. He was with Skiatron Electronics, TV Corp., and UAC Norden Division prior to joining IDI. He has served as Northeast Regional Director of *SID,* as chairman of the Mid-Atlantic Chapter, and was program chairman for the *SID* Sixth National Symposium.

Samuel Davis

Samuel Davis is presently a Project Engineer in the Data Systems Division of Litton Industries. He is engaged in the development of man-machine interface systems, character generation systems, and tactical data display systems. He obtained his BS/EE from Case Institute (1956) and did graduate work there, then was an Engineer in the Clevite Corp. Ordnance Div., in design of underwater acoustic systems. Recent work has included design of circuits and systems related to many activities, including amplifiers and character generators for use in both large and small CRT displays, as well as EL display systems, and has several patents pending.

Edward F. Rizy

Edward F. Rizy is a native of Bridgeport, Conn. He received the AB degree in Psychology from Fairfield University and the MA in Experimental Psychology from Fordham. From 1962-63 he worked with the Institute of Developmental Studies, New York Medical College, in test construction and administration. Since May 1963, as an Air Force lieutenant, he has been with the Display Techniques Branch, Rome Air Development Center, Griffiss AFB. He has written articles on the perception of casuality and on color coding problems. He collaborated on reports dealing with misregistration in additive color with minimal standards for TV symbology.

New Literature

Aerial Reconnaissance Cameras

Chicago Aerial Industries Inc., Barrington, Ill., is offering a 4-page brochure covering the KA-50 series of aerial reconnaissance cameras. This military-approved camera family features high-speed focal plane shutters, automatic exposure control, and interchangeable high-resolution lens cones in a series frame, 5 in. format.

The two-color brochure tells how the cameras are capable of gathering maximum intelligence under virtually any mission conditions, with a minimum of operator control. Specifications and dimension drawings are also included.

Circle Reader Service Card No. 69

A/D Conversion Device

A ten-page, two-color engineering catalog has been released by Theta Instrument Corp., Saddle Brook, N.J., describing a new method of analog-to-digital conversion.

The catalog covers theory, application, and full specifications for a precise servomechanism which transforms an incoming electrical signal into an illuminated digital display plus digitally coded (BCD) output. Employed in such applications as nuclear rod position indicators and load-cell digitizers, the instrumentation technique is inherently less expensive than methods in current use, according to Theta.

Circle Reader Service Card No. 70

Switches and Connectors

Switchcraft, Inc., Chicago, Ill., announces their new 24-page short form Catalog No. 66, which contains a basic listing of the complete product line of electrical switching and connecting components and accessories.

All data is condensed for easy selection of jacks, plugs, switches, connectors and audio accessories for commercial, industrial, and military applications. Nineteen items are introduced in the catalog, and a prepaid postal card is included to facilitate ordering complete engineering specifications on any of the wide variety of electronic components described in the catalog.

Circle Reader Service Card No. 71

Microwave Tubes

Litton Industries' Electron Tube Div., San Carlos, Calif., offers a 40-page 1966 Products Summary containing data on more than 300 microwave tubes and related equipment.

Included are complete specifications and photos on pulse and continuous wave magnetrons, crossed field forward wave amplifiers, planar triodes, M-type backward wave oscillators, klystrons, traveling wave tubes, and display devices.

Circle Reader Service Card No. 72

Gauss Chamber Assembly

Magnetic Shield Division of Perfection Mica Co., Chicago, offers data sheet #183, containing technical details, cutaway illustration, and exploded view of a new Co-Netic zero gauss chamber magnetic shield assembly which provides lower "0" reference for all forms of Hall detection devices and other magnetic sensing probes.

Circle Reader Service Card No. 73

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SYLVANIA ELECTRONIC TUBES
DIV., SYLVANIA ELECTRONIC PRODUCTS, INC.
SENECA FALLS, NEW YORK

TELEVISO ELECTRONICS DIVISION
DOUGHBOY INDUSTRIES
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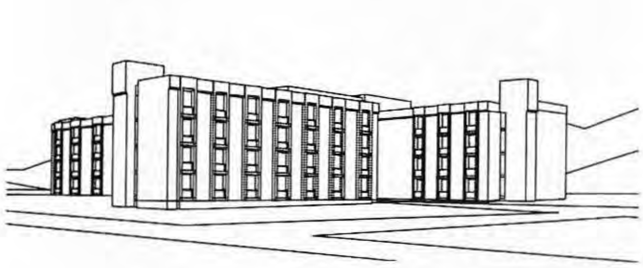
Would you believe a CalComp plotter and any computer can draw pictures like these in seconds?



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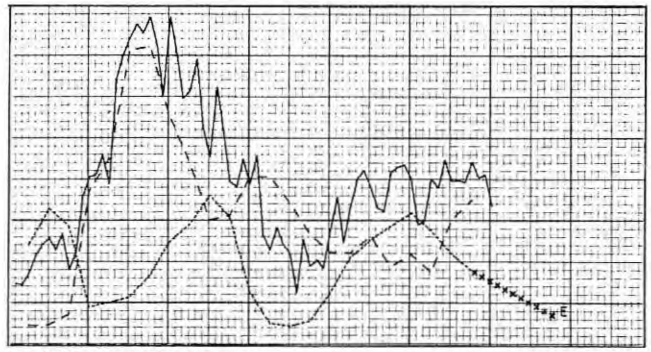
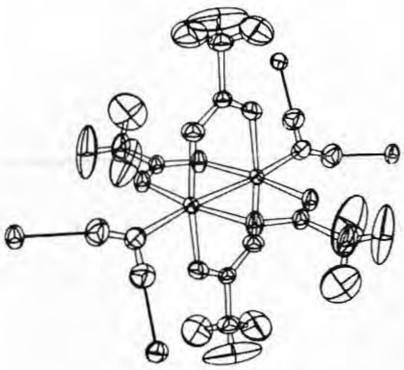
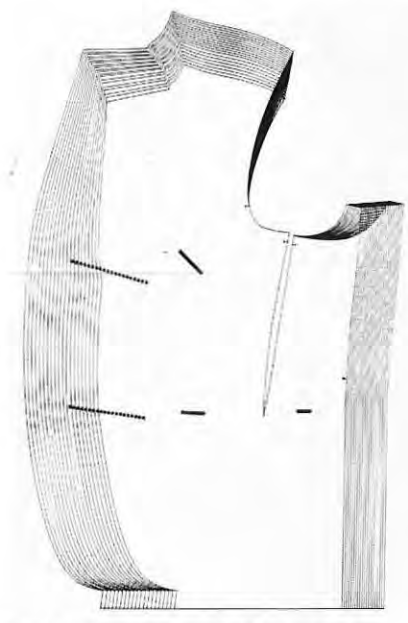


statistical trend charts



molecular structure diagrams



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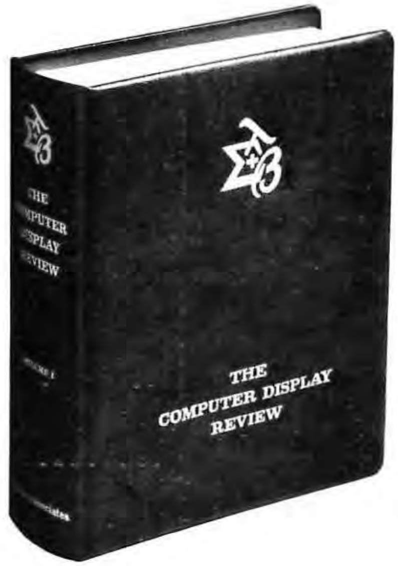

CAMBRIDGE, MASSACHUSETTS — Charles W. Adams, president of Adams Associates, announced today that the first issue of THE COMPUTER DISPLAY REVIEW, a publication of far-reaching significance to all who are interested in computer graphic displays, was mailed on August 1 to prepublication sponsors and subscribers. These include many agencies of the Federal government and armed forces, computer and display equipment manufacturers, industrial organizations, research and development laboratories, and university computation centers — a clear indication of the wide range of interest that alphanumeric and line-drawing displays hold for businessmen, industrialists and scientists.

In its many years of developing and working with computer-based display equipment and techniques, Adams Associates has long recognized the need for a single source of information and critical evaluation of this entire field. THE COMPUTER DISPLAY REVIEW answers this need. Divided into seven sections containing more than 500 pages of text, tabular and illustrative material, the information in it results from an intensive effort by Adams Associates during the past year to gather, analyze and evaluate data on all display equipment now available or under development in the free world.

"As consultants rather than publishers," Mr. Adams said, "we are offering not a book but a service. To keep our subscribers abreast of the latest developments in this rapidly expanding field, a full-time staff will continue its research, visiting equipment manufacturers and field installations. New developments in display hardware, software, applications and trends will be thoroughly evaluated and information on them released in the form of supplements every four months. In addition, abstracts of timely articles on applications and techniques as well as papers contributed to or written expressly for the REVIEW by well-known specialists will be included."

By making THE COMPUTER DISPLAY REVIEW available on a subscription basis to corporate sponsors, the substantial cost of producing it — which would be prohibitive for any one client — will be shared by interested firms and government agencies. The corporate sponsorship fee of $750 is a one-time charge which includes one annual $150 subscription to the REVIEW. All additional subscriptions and renewals are $150 a year. Since both the U.S. and Canadian governments are already corporate sponsors, all of their agencies are eligible for the $150 subscription rate. So too are all accredited universities, colleges and secondary schools, for which the corporate sponsorship fee has been waived.

For further information on THE COMPUTER DISPLAY REVIEW, please call or write to John T. Gilmore, Jr., Vice President.

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